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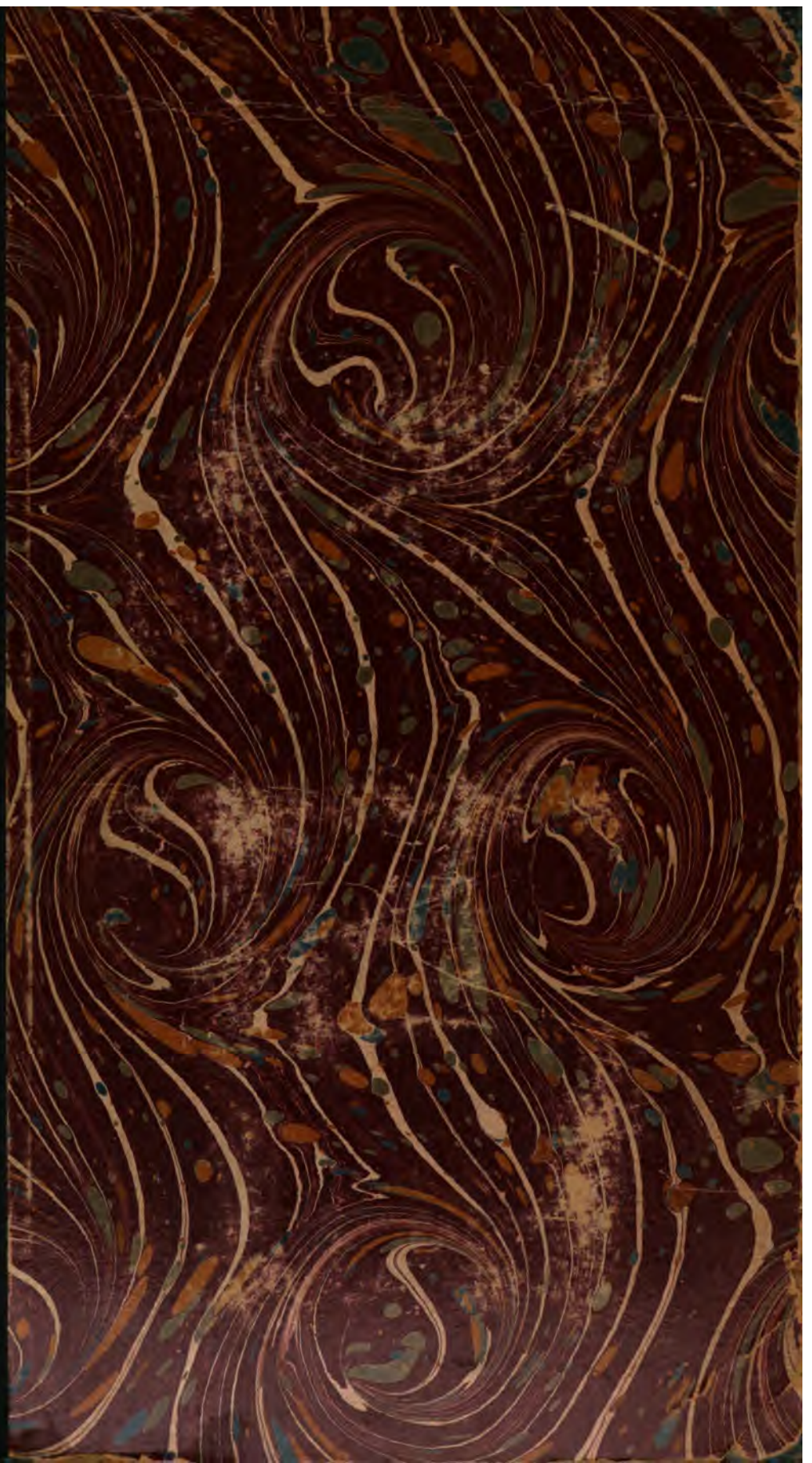
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THE RESTORATION
OF THE
ANCIENT IRRIGATION WORKS ON THE TIGRIS
OR
THE RE-CREATION OF CHALDEA

BY
SIR WILLIAM WILLCOCKS, K.C.M.G., M.I.C.E.
LATE DIRECTOR GENERAL OF RESERVOIRS, EGYPT,
MANAGING DIRECTOR OF THE DAIRA SANIEH COMPANY

BEING A LECTURE DELIVERED AT A MEETING OF THE KHEDIVIAL
GEOGRAPHICAL SOCIETY, CAIRO, 25th MARCH, 1903

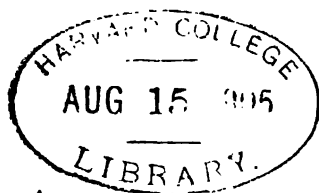
WITH TWO APPENDICES

APPENDIX A.—*Meteorological Information about Bagdad*
" B.—*An Address on "Egypt Fifty Years Hence"*

AND TEN PLATES

CAIRO:
NATIONAL PRINTING DEPARTMENT,
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PREFACE.

FOR the information about the Tigris and its canals contained in this address I am indebted to the fascinating "Memoirs of Commander Felix Jones, I.N."; Memoirs connected with Bagdad, Nahrwân Canal, Frontier of Turkey and Persia, Median Wall of Xenophon, Discovery of the Ancient Opis, and Topography of Nineveh, being selections from the "Records of the Bombay Government, No. XLIII.—New Series."—Bombay.—Printed for Government at the Bombay Education Society's press, 1857. These memoirs were placed in my hands by Mr. Spring Rice, the British Commissioner of the Public Debt at Cairo, to whom I am also indebted for much information connected with these regions.

Appendix A gives meteorological information about Bagdad, kindly supplied me by Sir John Eliot, K.C.I.E., the Director General of the Meteorological Department of India.

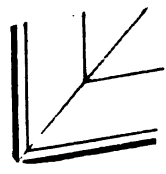
Appendix B is a reprint of my address on "Egypt Fifty Years Hence," delivered before the Khedivial Geographical Society at Cairo, 1902.

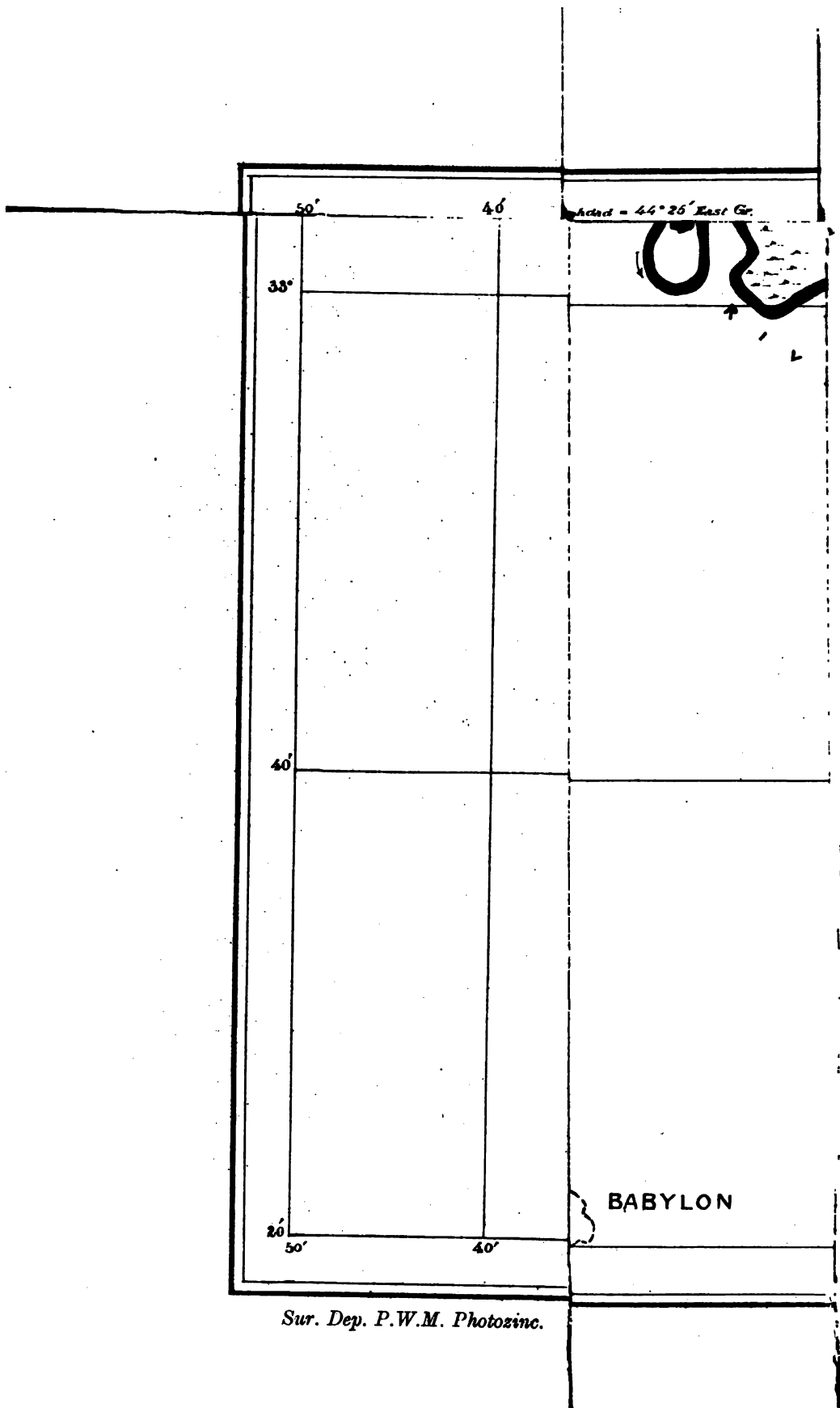
To Captain Lyons, R.E., Director General of the Survey Department of Egypt, I am indebted for the excellent reproduction of the maps and drawings. For all that is artistic and clear in the drawings I am indebted to Mr. Letchford. To Chélu Bey of the National Printing Press are due my best thanks for his usual loyal co-operation.

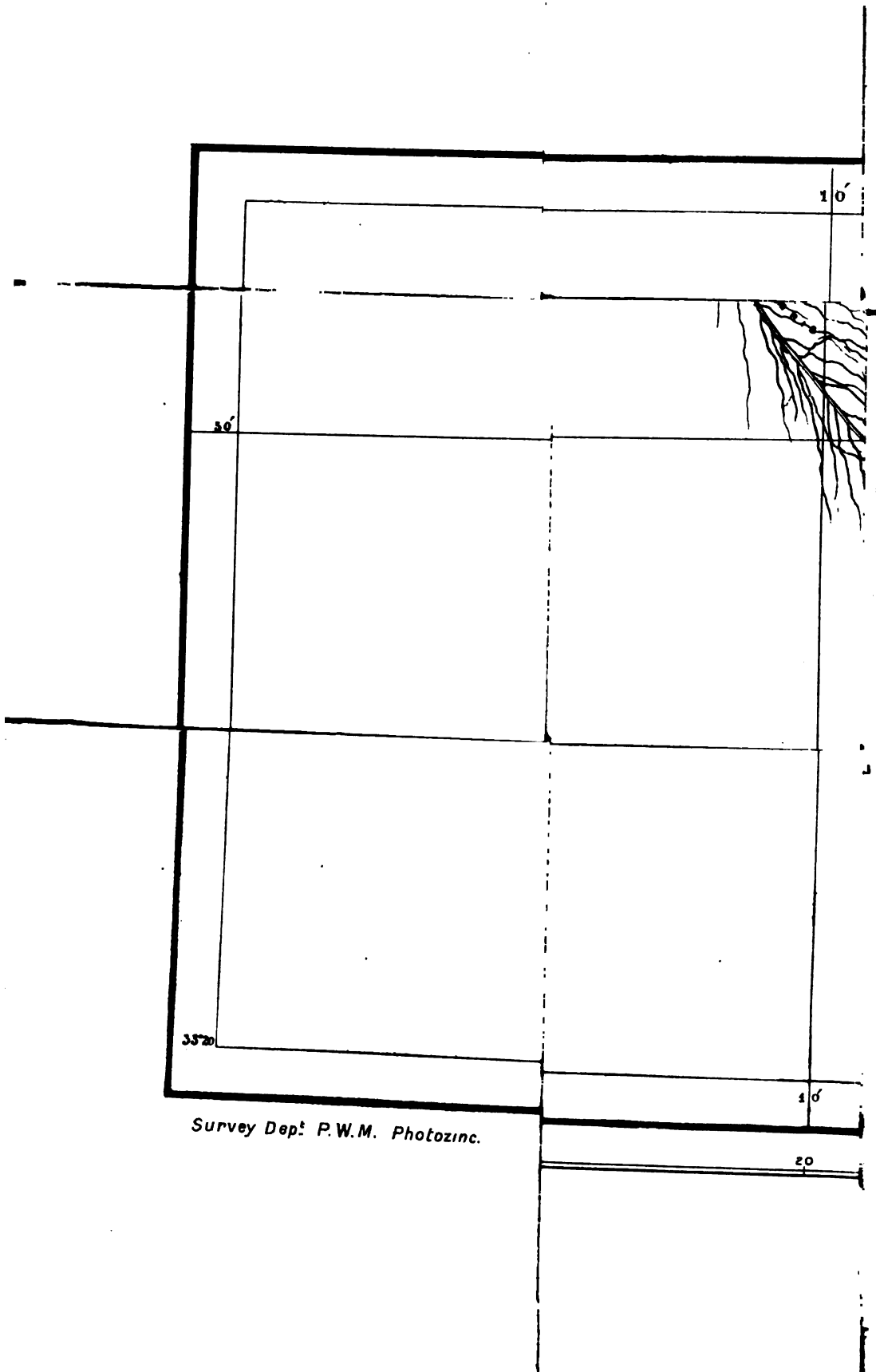
W. WILLCOCKS.

Cairo, 1903

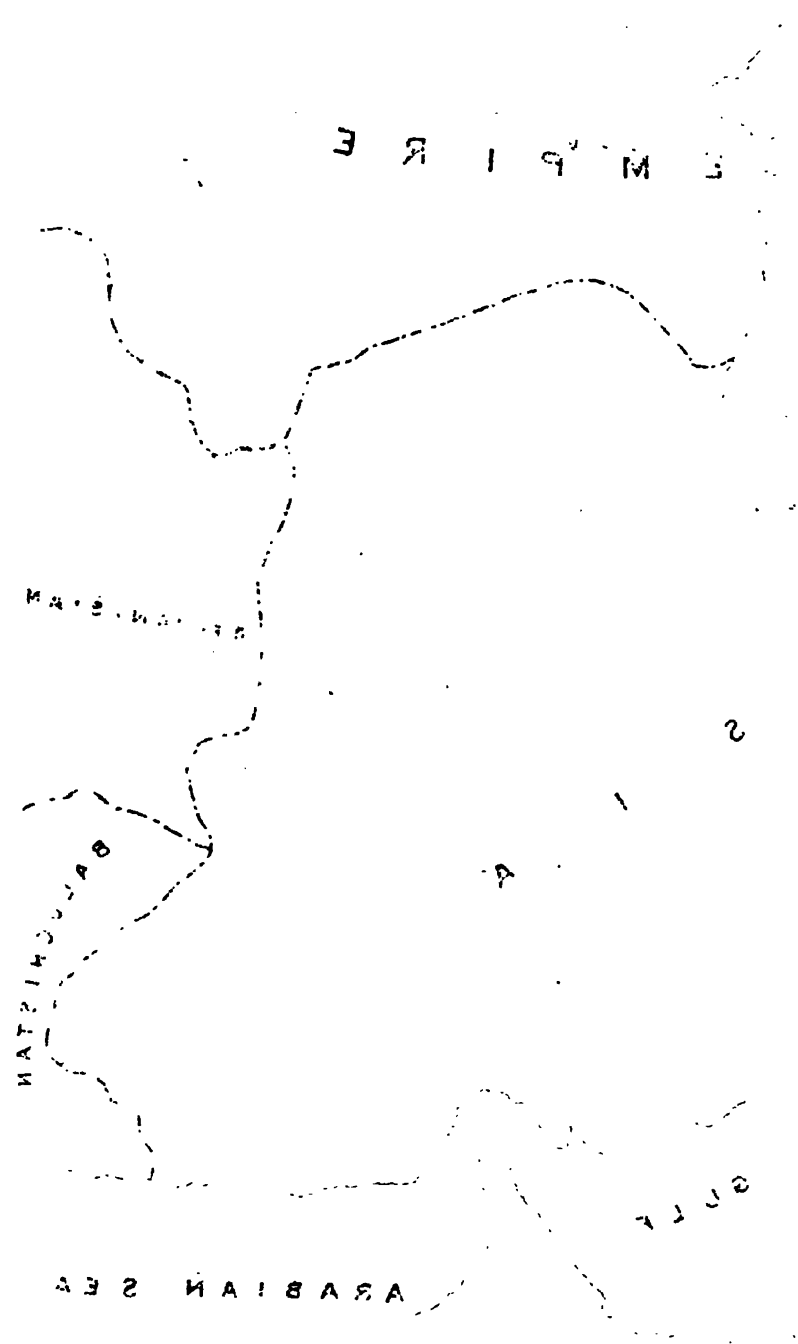
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THE RESTORATION
OF THE
ANCIENT IRRIGATION WORKS ON THE TIGRIS
OR
THE RE-CREATION OF CHALDEA.

"CURSED be Pharaoh who said in his pride 'Am I not Pharaoh, king of Egypt?' If he had seen Chaldea he would have said it with humility." Such were the words reported to have been uttered by Maimûn, the son and successor of Harûn-el-Rashîd, when he had ascended the Mokattam hill and seen the land of Egypt stretched below his feet. He undoubtedly exaggerated. Egypt will always remain the queen of irrigated countries; but next to Egypt may certainly be placed the wonderful land irrigated in ancient days by the Tigris. The resurrection of this old world irrigation is near at hand. The Bagdad railway is steadily advancing from the west, and European civilization is scattering before it the Arabian locusts which have so long held possession of these plains. It has occurred to me that a way might be found for commencing the railway from the side of the Persian Gulf as well as from the side of the Mediterranean, and thus enabling the two sections to meet on the Euphrates or the Tigris. Broad stretches of land were given to the Canadian railway company which connected the Atlantic with the Pacific across the North American continent. The Bagdad railway would need no concessions of lands measured

by thousands of square kilometres. One half of the million and a quarter acres of land which are uncultivated to-day on both sides of the Tigris above and below Bagdad would be amply sufficient.

Bagdad lies at a height of ~~66~~ metres above sea-level, removed 800 kilometres from the sea as measured on the Tigris, and 550 kilometres as the crow flies. Around Bagdad lies a country desolate to-day, but which was once the crown of the possessions of the powers which swayed the East. Here lay the treasury of the kings of the East. Wherever we go within 100 miles of Bagdad we are indeed on classic ground. Descending the river from north to south, we see first Dura, the intake of the great Nahrwân Canal, and the plain on which Nebuchadnezzar erected his golden image, probably to commemorate a thorough restoration of this very canal; then Tel Alig where the Emperor Julian died of his wounds, when the expulsion of the Romans from these regions meant the surrender of the Eastern world to the Persian kings; Opis, the wealthiest mart of the East for many generations; Bagdad, the capital of the Kaliphs, where Haroun el Rashid held his court; Ctesiphon, the ancient capital of the Sassanian kings of Persia; Seleucia, the capital of the Macedonian kingdom of the East; Cunaxa, where Cyrus the Younger was killed, and Xenophon and the ten thousand began their retreat through country intersected by a hundred canals; and finally Babylon itself, though this last city was on the Euphrates. Protected on the west by the Median wall, which was probably a canal bank, and on the east by the banks of the Nahrwân Canal, the country on both banks of the Tigris lay safe from the incursions of wandering Arabs, and was long held as the richest and most coveted part of the East. Just as king Menes turned the Nile out of its western channel and made it sweep the base

of the Arabian hills so as to protect his capital of Memphis from Arab marauders, so the Chaldean kings protected the rich fields and wealthy cities of the Tigris by the construction of giant canals.

The rainfall of the region is not ordinarily sufficient for agriculture. Appendix I contains the rainfall of a certain number of years obtained through the courtesy of Sir John Eliot, the head of the Meteorological Department of India. From these lists it will be seen that the rain falls in November, December, January and February; while it is rainless from May to October. The mean annual rainfall is 240 millimetres, though in 1894 there were 560 millimetres, while in 1899, 1900 and 1901 the annual rainfall was 90, 140 and 40 millimetres respectively. With such rainfall irrigation is absolutely necessary. Appendix I contains temperature, pressure and wind statistics as well as rainfall returns. The extremes of heat and cold which characterise this region will be greatly modified when the deserts have given place to perennially irrigated fields.

The slope of the Tigris from Bagdad to the sea is $\frac{1}{13000}$, practically the same as that of the Nile; while, however, the fine mud of the Nile has been laid on a gradual slope, the coarser mud of the Tigris has been deposited within the first 250 kilometres. This very action has rendered these 250 kilometres extraordinary fertile. Though the Delta of the Tigris cannot compare with the Delta of the Nile, the upper reaches are quite exceptionally fertile owing to the rich friable nature of the soil. They are like the soil on the foreshores of the Nile. I am indebted to the Memoirs of Captain Felix Jones, of the Indian Navy, for all the information which now follows. I only occupy the place of an irrigation expert explaining and elucidating the facts and observations of that extraordinarily capable man who for many years made Bagdad his

head-quarters and supplied the Indian Government with the most valuable information. These memoirs were placed in my hands by Mr. Spring Rice, the English Commissioner of the Public Debt in Egypt, and to him I here tender my best thanks for helping me with his exceptional knowledge of the nearer East. Politics I have nothing to do with. My ambition is to see ten blades of grass growing where none are growing to-day.

The Tigris rises in the hills to the south and west of Lake Van, and, flowing by the ancient Nineveh, traverses the Hamrin hills in the 35th parallel of latitude and enters the high-lying plateau of silicious conglomerate which lies at their feet. Through these conglomerates, the river passes in a trough some 15 to 25 metres deep, over a shingly bed with a velocity of some 2·5 metres per second. Near the site of the ancient Opis, at the 34th parallel of latitude, the river leaves the conglomerates and shingles and enters its Delta with a velocity reduced to 1 metre per second. In the first 30 kilometres, the Delta is composed of argillaceous marls, which then give place to the finer alluvium through which the river flows past Bagdad. At a distance of 80 kilometres below Bagdad the very fine deposits of the delta, accompanied by salt, find their place, and continue to the sea. These last lands are easily rendered too salt for cultivation, and cannot be compared with the friable deposits north and south of Bagdad, which are eminently suited for irrigation and cultivation. In high flood the Tigris overflows its banks from near Bagdad to the sea. Opposite Opis, the Tigris receives the Atheim as a left bank tributary, while the Dyala River flows into the Tigris near Bagdad. The latter river feeds numerous canals along its entire course.

The Tigris begins to be in flood towards the end of the winter; and as the spring and summer advance, the melting

snows in the high hills at the sources of the river and its tributary streams, add their volume and help to swell the flood. The Tigris with its snow-fed waters resembles the rivers of Upper India in the summer, and is eminently suited for perennial irrigation. The greater the heat, the greater the demand for water for irrigation, and the more plentiful the discharge from the melted snows.

The town of Opis bears to the Delta of the Tigris very much the same relation that Cairo bears to the Delta proper of the Nile; and just as Cairo has in its vicinity the great barrages or weirs across the Nile and the heads of the great canals which irrigate the 3,000,000 acres of Lower Egypt; so, in proximity to Opis, were situated the heads of the great canals which irrigated the Delta of the Tigris. Nature meant the spot as the starting-point of a great irrigation system.

In ancient days there were two great systems of irrigation starting from above the final rapids of the Tigris, so as to secure a good command of the country. To further insure the supply of water in the canals there were massive rubble weirs placed across the Tigris downstream of the canal heads. It is stated that Alexander the Great partially removed these weirs to secure the conquest of the country. When the conquest was completed, he doubtless restored them.

The two great systems were the Nahrwân system on the left bank, and that now known as the Dijeil on the right. In those days the Tigris was in its old bed and Opis stood on the left bank of the Tigris. I shall first describe the two systems, and then narrate the terrible catastrophe which in a few months turned one of the most populous regions of the earth into a desert; and finally I shall show how modern science will touch this region with her magic wand, and the waste places shall again become inhabited, and the desert shall blossom as the rose.

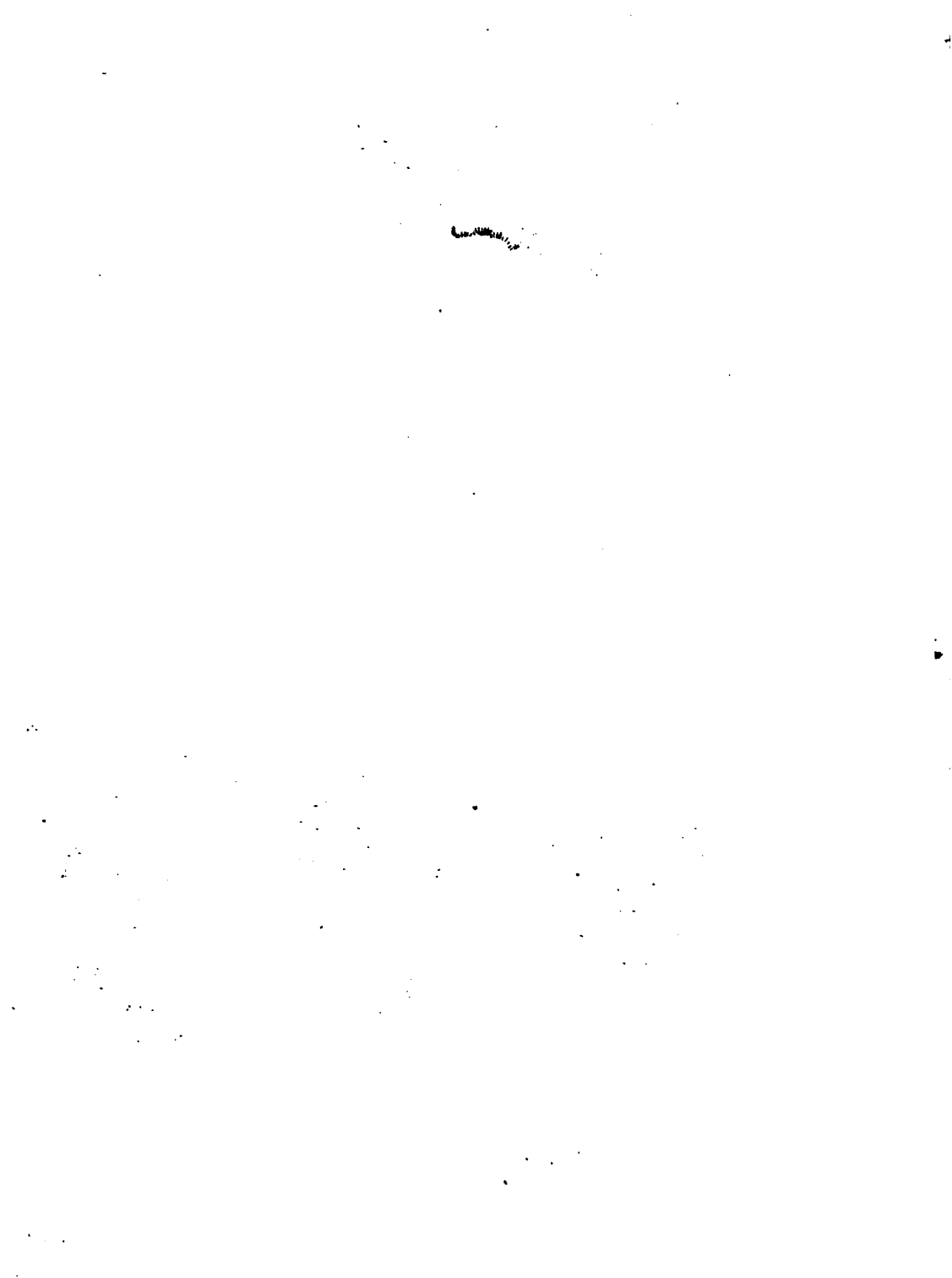
The "Nahrwân" or "Canal Keeper," or "Feeder," or "Rayyah," as we should call it in Egypt, fed the whole system of canals taken from the Athim and the Dyala and then continued its course for a length of 400 kilometres along the left bank of the Tigris. In its upper reaches it was known as the "Katul-el-Kesrawi" or "The Kaisers' Trench." Begun in the most ancient times, it was in its zenith in the great days of the Sassanian kings of Persia, and subsequently in the days of Harun-el-Rashed. Like very many canals, which need occasional silt clearances, it had two heads; so that when the clearance was being made of one head, the other supplied the water for the whole system. The upper head took out of the Tigris at Dura, and after a course of 60 kilometres was joined by the lower head which took off the Tigris at Kudesieh (Cadiz, "Kuds," the holy). At the junction were massive regulators known as Kantaret-el-Kasrawia or the "Kaiser's Bridge," whose remains are shown on Plate 5. Near where the upper head takes off from the Tigris is the "Kantara resasa," a massive stone weir of large stones clamped with lead (resâs). The lower head had a grand regulator whose ruins are shown on Plate 4. The modern Tigris flows over the ruins of this regulator.

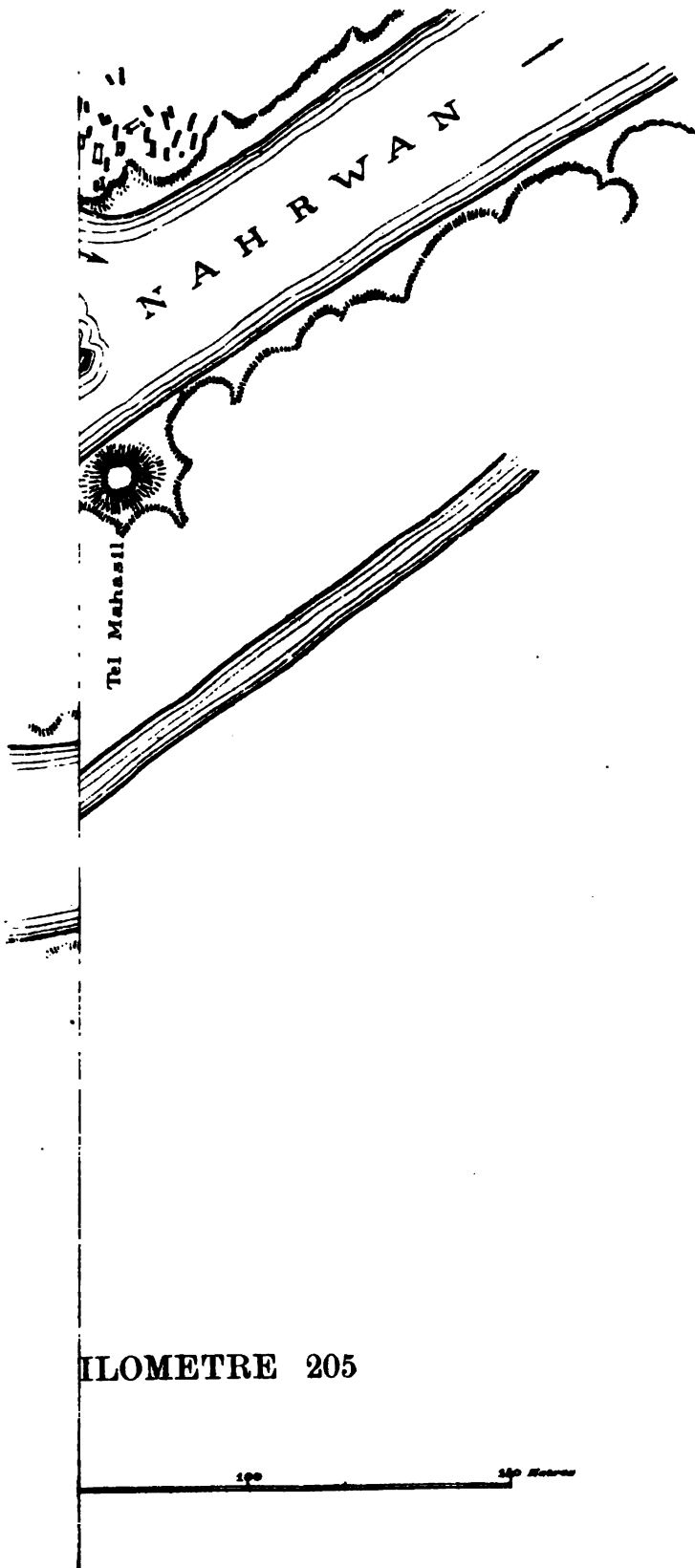
Between the 60th and 70th kilometres, the Nahrwân Canal is cut across by the River Atheim and has disappeared for a length of some 2 kilometres. In ancient days this action of the Atheim River was provided against in a truly ingenious way. The Atheim River traverses the Hamrin hills about 80 kilometres from the Tigris. A massive masonry dam some 17 metres high was built across the river, and its waters taken into two canals, the Nahr Batt and the Nahr Rathan. These canals irrigated the lands on both banks of the Atheim, and were finally led into the Nahrwân Canal by masonry regulators. Between the 70th and the 80th kilometres



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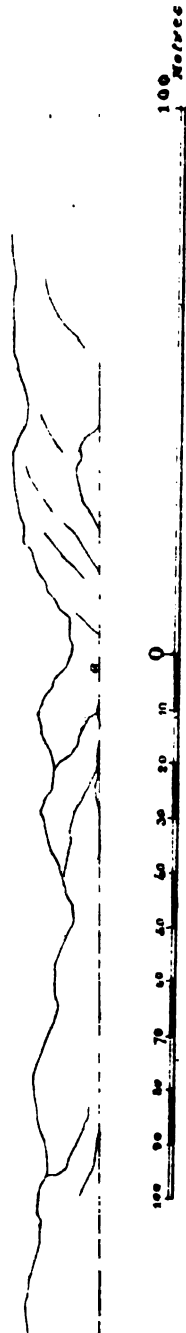
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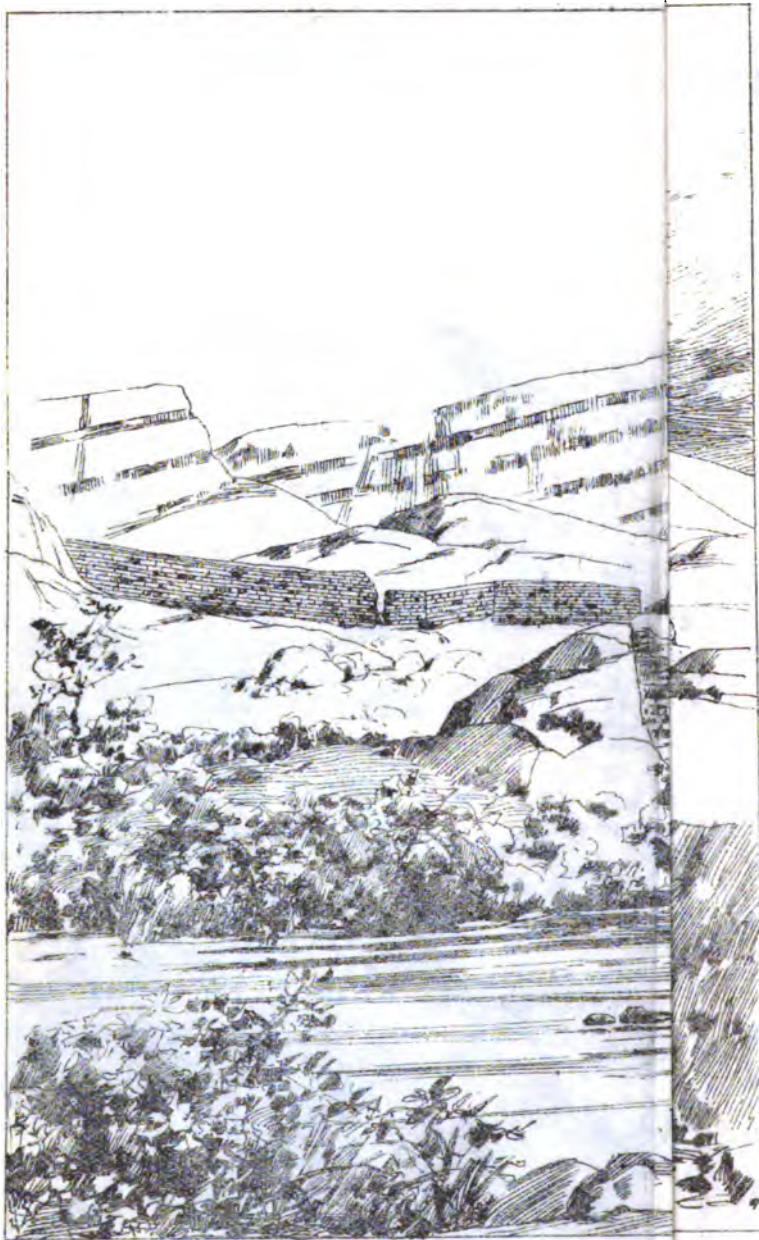






ATE 6.





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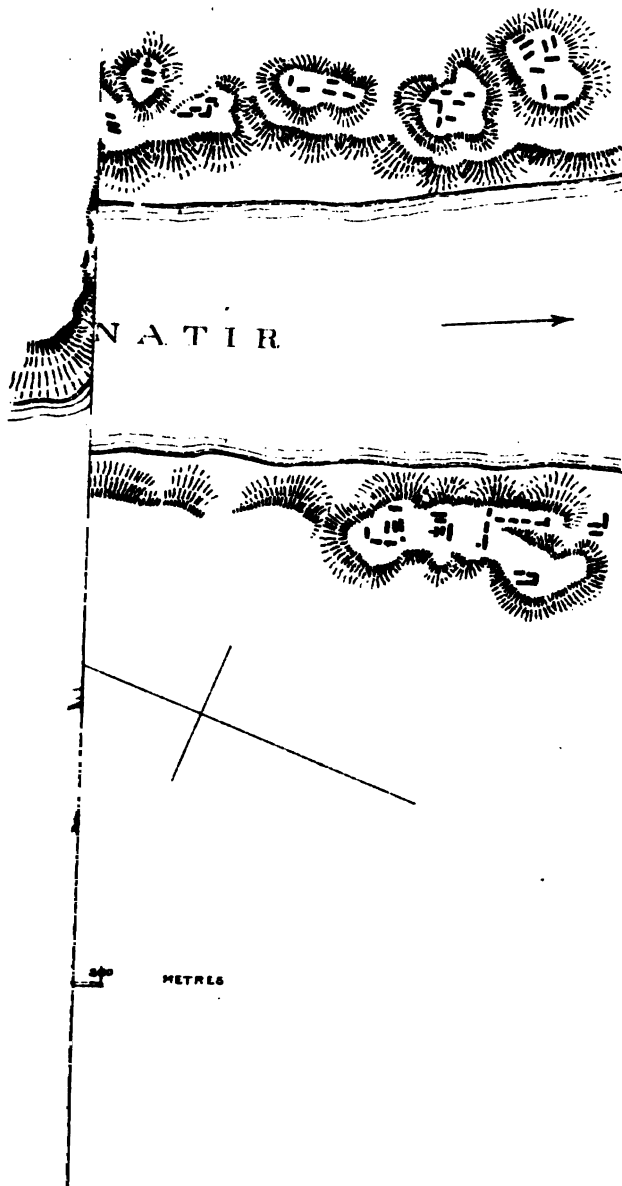
the Nahrwân Canal has been cut away by the modern Tigris and has disappeared. Near the 100th kilometre it has been filled with deposits brought down by the Khalîs Canal from the River Dyâla, and is cultivated over. In ancient days the Nahrwân took the tail waters of the Khalîs and carried them on. From the 120th to the 150th kilometre of its course, the Nahrwân Canal runs parallel to the Dyâla River and has practically disappeared. The ancient canal in this reach was constructed so that it might deliver water at a higher level at its 150th kilometre than the Dyala river could deliver it. This point will be returned to again. Introducing slight changes into the description given by Commander Felix Jones of the disasters which overtook the Roman army under the Emperor Julian, I should say that the "lofty dykes of the river," spoken of by the Roman historian, were the high conglomerate cliffs which bound the east valley of the Tigris north of Opis, while the "hills from which the archers of Persia insulted and annoyed the weary legionaries" could be none other than the high spoil banks of the gigantic Nahrwân Canal.

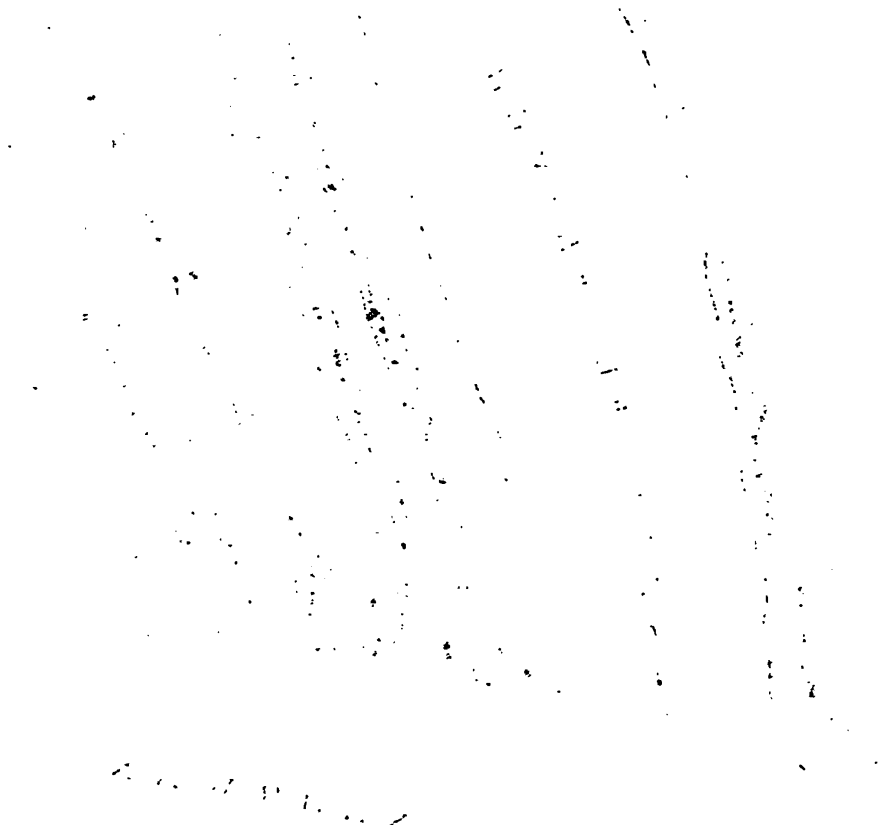
Opposite kilometre 153 of the Nahrwân Canal are the remains of the Beldei dam, which turned the waters of the Dyâla River finally down the Nahrwân. At kilometre 162 are the remains of an old regulator. From kilometre 160 to 210 we are opposite Ctesiphon, when the great arch of the vestibule of Nausherwan's palace is a landmark visible from far and a witness to the great days of the Sassanian kings. In this reach the Nahrwân Canal is studded with ruined cities, while minor canals lead off to the east and west with bewildering frequency. Near kilometre 200 are the remains of an old regulator, and of a second regulator at kilometre 210. From above the last, a very important canal takes off from the left bank; while shortly below the

last regulator, the Nahrwân Canal falls freely to a lower level. Up to kilometre 250, irrigation could be restored to a land prepared to receive it; while from kilometre 250 to kilometre 400, the country traversed by the ancient canals has become salted and will need reclamation as well as irrigation. This tract can certainly wait. The Kitab el Akalim, written about A.D. 970, describes the Nahrwân Canal as "flowing amid continuous extensive villages, date-groves and well-cultivated lands, and finally discharging into the Tigris a little below Badrai." And again: "This is the lowest and most considerable, and has well-constructed buildings on its banks. It flows amid cultivation and villages, and, in like manner, many branches emanating from it irrigate the country between it and the east bank of the Tigris. These copious branches reach unto the Tigris."

The Upper Nahrwân for the first 15 kilometres of its course is a trough some 15 metres deep and 20 metres wide, cut straight down through the hard conglomerate. The canal ran down this cut like a mill-race and at the 20th kilometre attained a width of 100 metres, and subsequently of 120 metres, which it maintained to kilometre 100. From kilometre 100 to 150, the Dyâla River carried the greater part of the supply, and the Nahrwân bed was reduced to 40 metres. From kilometre 150 onwards its bed was between 100 and 120 metres in width. Over long reaches the depth of the canal was from 5 to 10 metres. The lower head was about 100 metres wide. The canal must have been capable of quite crippling the Tigris when it was carrying its full supply. The widest canal in Egypt is 60 metres, and the deepest 10 metres. No Egyptian canal can compare with the Nahrwân in magnitude; nor indeed can any Indian canal.

The eastern system of canals has been called the Dijail system. This is in realty an ancient name of the Tigris,





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FIG. 9.



Sur. Dep. P.W.M. Photozinc.

and means to-day that the canals which go by this name have replaced in a way the ancient line of the Tigris. The old Dijail Canal was a fine work over 100 kilometres long and 50 metres wide. The present canal, which flows down the middle of the old bed, is between 5 and 10 metres wide. Plate 9 gives a drawing of the bridge over the Dijail, drawn by Commander Felix Jones. The proportions of the modern canal, which can barely utilise a single arch of the old bridge, need no further comment. Parallel to the last-mentioned canal was the Ishaki Canal and numerous other water-courses of less importance. All these canals irrigated the lands above flood level as far south as Bagdad. From Bagdad onwards the right bank of the Tigris is liable to inundation not only from the Tigris but even from the Euphrates in flood. To this question of the inundation of the country between the Tigris and the Euphrates and along both rivers I shall return later.

What was the real cause of the ruin of all this agricultural wealth and these great cities, and the creation of the vast deserts which we see to-day? An examination of the map will make it evident. Those who have seen the head works of the Ganges Canal at Hardwar in Northern India, where the rubble weirs across the shingly bed of the Ganges lead the stream past Hardwar into the Ganges Canal above the steep bluffs of Kankhal, will readily understand what I am going to say. Let such imagine what would be the fate of the great Ganges Canal if the Ganges River were to desert the Hardwar channel, flow down the Budh Ganga, and then turning abruptly westwards eat away the Kankhal bluffs until the canal was cut into by the river. It would mean ruin to the whole canal with its 500 kilometres of main channels and 3,500 kilometres of minor channels. Such a fate has overtaken the Nahrwân Canal.

The Tigris has a mean width of under 400 metres according to information kindly supplied me by M. Moritz, Librarian of the Khedivial Library at Cairo, while the lower heads of the Nahrwân Canal have a mean width of about 100 metres each according to the plans of Commander Felix Jones. To insure the supply of this great canal we are moreover informed that the Tigris had constructed across its ancient bed, downstream of the intake of these feeder canals, massive rubble weirs. To me it seems conclusive that, in Chaldea's evil day, the main stream of the Tigris deserted its ancient bed, followed the scoured and degraded bed of the canal whose regulating head had been swept away, and cut out a new channel for itself at right angles to its old course. A careful examination of the plans and levels can lead to no other conclusion. Once the river had changed its course, the old bed gradually silted up, the river ate away the feeder canal at the site of the regulator whose ruins to-day are in the bed of the river, and again ate away the main Nahrwân itself between the 70th and 80th kilometres. The ruin was complete. Feeble hands did what they could to repair the disaster. The Beldai dam across the Dyala was strengthened and the head of the Nahrwân Canal was removed to its 152nd kilometre. The feeble supplies of the Dyala River could alone be depended on, the Tigris gave no aid from its ample waters, and a once flourishing and world-renowned region became a desert. The ruin on the west bank was equally great. The weirs which had held up the waters of the Tigris in order to feed the canals, were turned, and the mighty canals dwindled away into the feeble water-courses of to-day. Commander Felix Jones well observes: "The summit of Opis, as we gaze around, affords a picture of wreck that could scarcely be conceived, if it were not spread at the feet of the beholder. Close to us are the dismembered walls of the great city, and

many other mounds of adjacent edifices, spread like islands over the vast plain, which is as bare of vegetation as a snow tract, and smooth and glass-like as a calm sea. This appearance of the country denotes that some sudden and overwhelming mass of water must have prostrated everything in its way, while the Tigris, as it anciently flowed, is seen to have left its channel, and to have taken its present course through the most flourishing portion of the district, severing in its mad career the neck of the great Nahrwân artery, and spreading devastation over the whole district around. Towns, villages and canals, men, animals and cultivation, must thus have been engulfed in a moment, but the immediate loss was doubtless small, compared with the misery and gloom that followed. The whole region for a space of 400 kilometres averaging about thirty in breadth, was dependent on the conduit for water, and contained a population so dense, if we may judge from the ruins and great works traversing it in its whole extent, that no spot in the globe perhaps could excel it. Of those who were spared to witness the sad effects of the disaster, thousands, perhaps millions, had to fly to the banks of the Tigris for the immediate preservation of life, as the region at once became a desert, where before were animation and prosperity. The ruin of the Nahrwân is indeed the great blow the country has received. Its severity must have created universal stupor, and was doubtless followed by pestilence and famine of unmitigated rigour, owing to the marshes which accumulated annually in the absence of the dams, on each spring rise of the river."

We have dwelt long enough on this picture of ruin and disaster. It is recorded of old that men journeyed from the East and found a resting-place in the plain of Shinar. Our modern world looks as a rule to the West for colonists and developments, but here in Mesopotamia we are in no white

man's land; and it is far more probable that men will again come from the East than that they will come from the West, to repeople and renew this ancient land. The Bagdad railway will traverse these regions—its rails will be laid on the banks of a renewed and remodelled Nahrwân Canal, and life and prosperity will again be seen in this land of great vicissitudes. Shall the canal be made with British capital extending its hands from the Persian Gulf, or with German capital coming from the West? Speaking financially, shall the canal be known as the Katul-il-Kaiser-i-Hind, or Katul-il-Kaiser-il-Almaigna? Or, as of old, Katul-il-Kesrawi, "The trench of the Kaisers." The construction of these great canals will create along the line of railway a country as rich as Egypt, whose rents will pay for both railway and canals, and leave a surplus which only those can realise who have been in intimate touch with Egyptian agriculture. Labourers from India and possibly from Egypt will dig the canals, construct the weirs and regulators, and then settle down in millions to reclaim and cultivate these lands potent with future wealth, just as though they were in another Punjâb or another Egypt.

The first works to be constructed will be a couple of rubble weirs upstream of Opis across the head of the modern Tigris. On the right bank the ancient Tigris will be maintained as a powerful canal just as the Damietta Branch of the Nile is maintained by the barrage across the Rosetta Branch of the Nile north of Cairo. The new head of the Nahrwân Canal will be opposite kilometre 50 of the upper head. The Atheim River will probably be treated as the old Chaldean engineers treated it. Between kilometres 70 and 80, a new channel will be dug for the Nahrwân Canal, and powerful spurs will prevent the Tigris from further encroaching on its left bank. The Khalis Canal will be provided with a

superpassage; the Dyâla River will be utilised for the irrigation of the lower lands towards Bagdad, while the higher lands will have a new course excavated for the Nahrwân Canal. It is evident from the descriptions of the channel of the Nahrwân Canal below kilometre 153 that the Dyâla River was too low to properly take up this irrigation. A new channel from kilometre 120 to kilometre 150 will deliver the water at a high level, and enable the Nahrwân Canal from kilometre 160 to kilometre 250, to again irrigate the rich plains past Ctesiphon and Seleucia. Beyond kilometre 250 and on to kilometre 400 of the ancient canal, lies a tract of land which, as far as I understand the descriptions of the country, has become much salted, and must wait. With cements and mortars, of which the ancients knew nothing, with the powers of steam and electricity at our disposal, with blasting powders and dynamite, and above all with labour-saving machinery and dredgers, we shall be able in our day to accomplish in a score of years as much as a whole dynasty of ancient kings could not have accomplished with hundreds of thousands of prisoners and *corvée*.

To enable a true estimate to be made of the exact nature of the works and their cost, there lies much information to be collected by brigades of engineers working under a capable chief—such information as only experts can gather in through months of patient observation and field work—exact gauge readings of the Tigris, Atheim and Dyâla Rivers; discharge diagrams; analyses of the waters of the rivers; field maps of the soils; contoured maps of the country on which to lay down the alignments of the canals, and the dimensions of the cross-drainage works; soundings of the rivers, and borings of their beds; examination of the building materials available to enable designs to be made of regulators and escapes, weirs and locks, syphons and superpassages, and all the details

which accompany a well-conceived project. Such works it will take a couple of years to collect; but I have not considered it unwise, with the aid of experience and prescience acquired in a lifetime of devotion to irrigation works, to make a rough preliminary estimate of what such works would cost and what would be their probable results, so as to encourage capital to pay for the collection of that detailed information whose outlines I have just described.

The area of first class land, waiting only for water to yield at once a handsome return, I estimate as follows:—

West of the old Tigris	280,000 acres.
Between the old and new Tigris	160,000 „
East of the Tigris, north of Bagdad	420,000 „
„ south of „	420,000 „
Total... ..	<u>1,280,000 „</u>

The cost of the works, discounting all assets, I estimate roughly as follows:—

Main canal 200 kilom. × 500 sq. met. = 100,000,000 c. m.	
Earthwork, main canal... ..	£2,000,000
Weirs on the Tigris	600,000
Masonry works, main canal, $\frac{1}{2}$ the earthwork	1,000,000
Minor canals, 1,280,000 acres @ £3 per acre	<u>3,840,000</u>
Total... ..	£7,440,000
Add contingencies	<u>560,000</u>
Grand Total... ..	<u>£8,000,000</u>

$$\text{Cost per acre} = \frac{8,000,000}{1,280,000} = £7 \text{ per acre.}$$

$$\text{Value of the land } 1,280,000 \text{ acres @ } £30 = £38,000,000$$

$$\text{Rent per annum... } 1,280,000 \text{ acres @ } £3 = £3,840,000$$

If of this sum nearly a half is spent in maintenance of the canals, we have a net return of £2,000,000 per annum or 25% on £8,000,000 of capital. Let those who know Egypt say whether they consider such figures as too sanguine.

I have so far only contemplated the high-lying lands at the beginning of the Delta of the Tigris, as I consider these lands the most valuable possession in the whole of this region; but in addition to these we have the swamped, partially reclaimed in parts, but generally barren lands which lie between the Euphrates and the Tigris. These lands can never have been comparable with the rich tracts near Bagdad which were the eye of Chaldea during the whole time of its prosperity; but they were traversed by great canals and irrigation works in old days and were doubtless cultivated and capable of supporting a population of no mean degree. Why do they lie desolate and marshy, and swamped and barren to-day? The changing of the course of the Tigris has in no way affected them. Their destruction is due to other causes, which in themselves are interesting enough, though not equal in interest to the giant catastrophes we have recently contemplated. It will be remembered that I stated a short time ago that the high overflows of the Euphrates reached as far as the Tigris from Bagdad northwards. From Bagdad northwards for a distance of some 150 kilometres the Tigris and the Euphrates run parallel to each other at a distance of about 50 kilometres; the two rivers then separate; the Tigris goes far eastwards, while the Euphrates continues its course. In this reach the Euphrates flood comes up to the Tigris, and the canals run generally from west to east. From its eastern bend, the Tigris throws off the great Hai Canal as an escape towards the Euphrates. Whatever difficulties may exist in the lower lands where the rivers are far apart, there should be no great difficulty in reclaiming and cultivating the rectangle of 150 kilometres multiplied by 50 kilometres between Bagdad and Babylon. The area of this tract is 1,500,000 acres, or about half that of Lower Egypt.

When the ancient Chaldeans—the men who travelled from the East and found a resting-place in the plain of Shinar—first settled in these regions, they must have found the Tigris and the Euphrates flowing in well-defined and capacious beds. Such capacious beds all silt-laden streams naturally form for themselves when not interfered with by external agencies. There were occasional heavy inundations of the country, and occasional droughts, but generally the streams kept within their channels. Such a state of affairs in a dry climate like that of Mesopotamia, was eminently suited to irrigation, and the early settlers must soon have undertaken irrigation works. As the population and resources of the region increased, the irrigation canals became larger and larger until eventually the whole face of the country was covered with gigantic canals, and the amount of water withdrawn from the rivers must have greatly exceeded that left in the main streams. The main rivers accommodated their beds and channels to suit the new conditions and gradually dwindled away. Weirs and obstructions to raise the water levels in years of insufficient supply still further told against the rivers; until eventually the rivers were quite unable to carry the waters when not relieved by the canals. Dykes along the river banks protected the country from occasional inundations, but the chief protection existed in the well-maintained canals which carried between them no inconsiderable portion of the floods. In the unsettled times with which for many generations these regions were cursed, the dykes were swept away, the canals silted up at their heads and were choked with weeds lower down their courses, and the rivers found themselves quite incapable of carrying the extra supplies thus thrust upon them. The country became a swamp. Those waters which had once “nourished her and run about her plantations, and sent out channels unto all

the trees of the field" now stagnated, and became as great a curse as they had been a blessing. Such is this region as we see it to-day. It has for us in Egypt a deep warning which we would do well to heed in this our day of unexampled prosperity. Basin irrigation withdraws the waters from the Nile at the beginning of the flood, but returns it free of deposit at the end of the flood. Such clear water is especially capable of keeping clear the channel of the Nile, and it has thus happened that after 7,000 years of basin irrigation the channel of the Nile is as capacious as it was when Menes first began his canals and dykes. Now, however, that perennial irrigation is gradually supplanting basin irrigation, and weirs and obstructions are multiplying in the Nile, we are imitating the ancient Chaldeans on the Tigris and the Euphrates, and we must beware of letting the channel of the Nile dwindle away in any respect. Careful cross-sections should be taken of the river every year, and if any appreciable diminution of the channel is taking place anywhere, steps should be taken to remedy it at once before the evil has been allowed to assume any proportions. If we carelessly neglect these precautions we have only to turn to the deltas of the Tigris and the Euphrates to learn what injudicious perennial irrigation can do to ruin a country whose formation is deltaic and therefore capable of being ruined.

We now return to the problem of reclaiming the country between the Tigris and the Euphrates and between Bagdad and Babylon. We can almost look on the country with the same eyes that king Menes looked on the Nile Valley when he first determined to reclaim and cultivate the whole country, while as yet there were no dykes and no canals, and the whole valley consisted of arid plains, sand-dunes, marshy jungles and reclaimed enclosures—all liable to be swept every

eight or ten years by a mighty inundation. Of Egypt at this stage of her history I have often said "The seeds of future success lay in the resolve of king Menes' engineers to confine their attention to one bank of the river alone. It was the left bank of the river which history tells us was first reclaimed. A longitudinal dyke was run parallel to the stream, and the whole left bank was no longer at the mercy of the flood. Meantime, the whole of the right bank and the trough of the river itself were allowed to be swept by the floods. It must have been on this wild eastern bank that were conducted all the hippopotamus hunts which are crowded on the wall-pictures of buildings of the early dynasties." Similarly I should say of this tract that the seeds of future success will lie in the resolve to confine the attention to one bank of each of the rivers. From the highest point where the waters overflow let a dyke be run down the east bank of the Euphrates and another down the west bank of the Tigris, and let these dykes be continued to a point below Babylon on the Euphrates and up to the great bend on the Tigris. If the overflow of the great rivers was allowed to stretch westwards on the Euphrates and eastwards on the Tigris, the area between the two rivers might be taken up, provided with canals and drains, and secured against drought by Egyptian weirs across the Tigris and the Euphrates. As I have no helping hand like that of Commander Felix Jones to guide me in this tract, I shall make but a rough attempt to estimate the cost of such works. According to all maps and descriptions, the assets in the way of existing works are very great, and I am moreover informed that His Majesty the Sultan of Turkey has already commenced successful reclamation works on a large scale on the lands most easily reclaimable near Babylon.

Judging from the expenditure incurred in Egypt on the

construction of dykes, canals and drains, we may say that such works in the area between the Euphrates and the Tigris would cost, on an Egyptian basis, £1 per acre for head works and weirs, 10s. per acre for dykes, £2 10s. per acre for canals, and £1 10s. per acre for drains, or a total of £5 10s. per acre. These figures are not arbitrary, but have been taken from my book on "Egyptian Irrigation," and have been calculated for Egypt with the greatest care and attention to details after a study of the works lasting over fifteen years. We have already seen that the mean slope of the Tigris is the same as that of the Nile, so that we are in a position to compare, however roughly it may be, one delta with the other; while with respect to these swamped lands under immediate consideration we have yet another guide. The resurrection of the low-lying lands of the Nile delta, known as the "Berea" or the waste land, utterly neglected and abandoned through a thousand years of ignorance and mismanagement, until the British occupation of Egypt woke them up with a start, is a valuable gauge of what we may expect from these equally long-neglected and derelict lands on the Tigris and Euphrates the moment they are touched by the wand of the intelligent reformer. Money by itself has done little in Egypt, it has been the intelligent expenditure of money during the last twenty years which has made Egypt enter on that path of progress and expansion which has arrested the attention of the world.

As a special difficulty in connection with the reclamation of the lands between the Tigris and the Euphrates one hears it frequently stated that between Bagdad and Babylon the waters of the Euphrates in flood reach right up to the Tigris. This swamping, however, is for and not against reclamation. Much of the salt must be washed off these lands. To those familiar with land reclamation it is well known that dry

salted lands are more difficult to reclaim than wet swamped lands. This is even the case in Egypt where the alkali salts are all nitrates and sulphates. Where the salts are the dreaded carbonates, no paying method of reclaiming such lands has as yet been discovered. If the salted lands below the 250th kilometre of the Nahrwan Canal on the left bank of the Tigris consist of sulphates and nitrates, these lands will in time be reclaimed, but if the carbonates of soda and potash are present in large quantities no reclamation need be attempted with our present knowledge of such soils.

I say this of the clay lands below the 250th kilometre of the canal, as fine clay soil when salted is difficult to reclaim. Of the sandy clays which compose the head of the delta and which are traversed by the first 250 kilometres of the canal, the reclamation will be speedy indeed if any is needed. In connection with this subject, Mr. Means' description of some of the alkali plains of the Western States of America given in the publication of the "Division of Soils of the United States Ministry of Agriculture" for 1900, might be studied with great profit. With the swamped lands, however, we are on different ground. Both in Egypt and in the Valley of the Po we have much to guide us. Whether the main drains are in embankment or in cutting is equally indifferent. The important point is, that numbers of small pumps should be placed on the banks of the main drains, draining small areas and discharging direct into the mains. Such pumps should be actuated by one central electric station for reasons of economy. The results of such drainage would be immediately apparent. The early failures of large reclamation works were nearly always due to the extensive areas drained by single installations. Electricity to-day has come to the aid of drainage as it has to that of every department of industry in the world.

Waste land in Egypt, when protected from floods, and further reclaimed at a cost of £3 10s. per acre, or at a total cost of £9 per acre, is worth between £30 and £40 per acre. When valuing the land along the Nahrwan Canal at the head of the delta of the Tigris I took the figure of £35 per acre which was less than half that of similarly situated land in Egypt where the values run from £60 to £100 per acre; so now for purposes of calculation I shall take the value of this land when reclaimed as worth less than half that of similar land in Egypt, or at £15 per acre. For the 1,500,000 acres of land between the rivers we have therefore, discounting all assets, an estimated expenditure of £13,000,000 and an estimated return of £22,000,000.

Summing up the figures for Upper Chaldea, or the lands at the head of the delta of the Tigris, and for the swamped lands of Lower Chaldea between Babylon and Bagdad, we have a total area of 2,800,000 acres, an expenditure of £21,000,000, and a return of £60,000,000. These figures may seem large; but we are in one of the most famous agricultural tracts of the world, a tract whose past history justifies us in expecting that great results will follow if we bring to the solution of our problems the same wisdom which the wise men of Chaldea brought to the problems of their day. It is not improbable that the wisdom of ancient Chaldea had its foundations in the necessity of a deep mastery of hydraulics and meteorology to enable the ancient settlers to turn what was partially a desert and partially a swamp into fields of world-famed fertility. Their task was certainly easier than ours, but we enter the field with advantages ancient Chaldea had no conception of.

If we were to adopt the rates at which similar works were executed in India we should have to divide every figure representing costs by 4; we should, however, have to divide

the value of the land by 2. I say by 2, for though land in Egypt is four times as valuable as irrigated land in India, still I have already halved the value of land in Egypt in my preceding estimates. With these figures before us, we should stand thus:—

	Acres.	Cost of works.	Value of land.
Upper Chaldea...	1,300,000	£2,000,000	£19,000,000
Lower Chaldea...	1,500,000	£3,250,000	£11,000,000
Total...	<u>2,800,000</u>	<u>£5,250,000</u>	<u>£30,000,000</u>

Situated as Chaldea is, an oasis in the middle of vast deserts, I should think its conditions would approach rather to those of Egypt than to those of India.

The delta of the Tigris and the Euphrates contains over 5,000,000 acres, an area as large as that of Egypt. Once reclamation has been successfully undertaken on a part of the area and the way shown to the attainment of stable agricultural wealth, capital will doubtless be as ready to take advantage of the position in Chaldea as it is to take advantage of the situation in Egypt. Egypt bears lightly to-day its debt of £20 per acre, of which not one-half represents money honestly spent on the development of the country.

In considering the lands between the rivers I have so far only considered the lands by themselves, as though they had nothing to do with the railway, but it must not be forgotten that every acre of land reclaimed and cultivated will bring in a direct return to the railway. Lying along the every path of the railway which is to connect the East with the West, Chaldea will be in a position to transport directly to the Mediterranean the produce claimed by the West, and to the Persian Gulf the produce claimed by the East. With an increase of population and prosperity, Chaldea, situated as she will be, an oasis in the midst of an arid land irrigated

by snow-fed rivers whose supplies never fail and traversed by the railway which will join East to West, will undoubtedly experience that same wave of prosperity which is passing over Egypt, the other similarly situated land. When this comes to pass, even in degree, we shall doubtless find that the rich lands of Upper Chaldea will have begun to rise from £35 to £80 per acre, while the poorer lands of Lower Chaldea have also begun to rise from £15 to £35 per acre. With communications by railways and branch agricultural railways as we know them to-day, the failure of the Tigris or the Euphrates at certain seasons of the year to accommodate its navigation, will in no wise afflict the country. In all arid and semi-arid lands, the watchword should be "Rivers for irrigation, and railways for communications." You cannot both use the waters of the rivers for irrigation, and also leave them in the streams for navigation. With railways, we shall never find ourselves situated as Alexander the Great was, when he had to remove the weirs on the Tigris at the head of the Nahrwân Canal, in order that sufficient water might find its way down the Tigris itself, to enable him to navigate it from the Persian Gulf to the vicinity of Opis. In connection with this question of navigation on the Tigris, it may be of interest to note that in Egypt to-day, with its railway service, the question of summer navigation is never considered; and yet in Egypt, navigation has great advantages. The current is always from the south and the wind is nearly always from the north, so that both up and down navigation are equally easy. In Chaldea, on the contrary, the current and the wind are both from the north, and upstream navigation for sailing craft must of necessity be arduous.

Though a life-long experience of irrigation in tropical and semi-tropical countries, and an exhaustive examination of

one of the most suggestive works I have ever read, have, I think, justified me in drawing your attention to a country with a world-known past and, let us hope with, a world-known future; still they have done no more than enable me to put down in the roughest outlines the probable future prospects of the country to be traversed by the Bagdad railway. The figures I have put before you, however, are sufficiently attractive to encourage the companies undertaking the railway to make a thorough hydraulic survey of the Tigris and Euphrates deltas, and to estimate separately the cost and value of the conversion of Upper and Lower Chaldea into irrigation centres like Upper and Lower Egypt. These surveys should, I contend, run side by side with the undertaking to find the best alignment for the railway.

If one and a quarter millions of acres of land are taken in hand in Upper Chaldea, and the same area in Lower Chaldea, four brigades of engineers in the north and four in the south, should, under capable direction, be able in two years to collect ample information to prepare definite projects and accurate estimates of costs. If each brigade consisted of four engineers under a chief, working for six months per annum at surveys, levels, discharges, river gauges and soil surveys, and plotting and mapping the work during the remaining six months of each year, the cost of the preparation of the project, including establishment, travelling expenses, plans, calculations and estimates would not exceed £50,000. Such a sum should not stand in the way of the settling of so important a point as the restitution of the delta of the Tigris and Euphrates on the eve of its being traversed by the Bagdad railway.

Indeed it would be an irreparable mistake if the railways were aligned and constructed independently of the irrigation canals, and if by some ill chance the railways traversed one

part of the delta, and the profitably irrigable part of the delta were to lie elsewhere. As always, I turn to Egypt for an example. In Egypt the railways and canals are designed together; the canals preceding the railways and settling their locations. If such a course be followed in Chaldea, the railways will aid the prosperity of the canals, and the canals of the railways; the canals will be able to devote themselves entirely to the development of agricultural wealth, and the railway will transport the agricultural produce by the cheapest and most favourable route. We shall not hear of complaints of navigation against irrigation, and of irrigation against navigation, which are so often detrimental to both agriculture and communications.

While reading the description of the Median wall of Xenophon with the meteorology of the country before me, it has seemed to me that this defensive work itself must have been a canal bank, or the defenders were likely to have died of thirst. With railways we need fear no such calamities nowadays, but in arid lands such as we are contemplating in Upper Chaldea there is wisdom in keeping the railway and the canal side by side. Deserts have necessarily to be traversed by the railway where no canals can possibly be made, but the reduction of such lengths of railway to a minimum is undoubtedly the soundest finance.

In contemplating the minor details of the works necessary for the restoration of the ancient irrigation on the Tigris we have apparently travelled far from our historic standpoint and from the ancient glories of the classic land which claimed our attention at the beginning of this address. But through such detailed study lies the only way to the goal before us. Keeping in view the majesty of our work like some snow-clad peak on whose summit we hope to stand, we must make our feet sure on the humbler ground on which we stand. And

we have much to encourage us. We have before us the restoration of that ancient land whose name was a synonym for abundance, prosperity and grandeur for many generations. Records as old as those of Egypt, and as well attested, tell of fertile lands and teeming populations, mighty kings and warriors, sages and wise men, over periods of thousands of years. And over and above everything else, there is this unfailing record that the teeming wealth of this land was the goal of all eastern conquerors, and its possession the crown of their conquests. The eastern power which held this land in old historic days held the East; the power which lost this land lost the East. A land such as this is surely worth resuscitating. Once we have apprehended the true cause of its present desolate and abandoned condition we are on our way to restoring to it its ancient fertility. A land which so readily responded to ancient science and gave a return which sufficed for the maintenance of a Persian court in all its splendour will surely respond to the efforts of modern science and return many-fold the money and talent spent on its regeneration. To-day, however, the works must be conceived by the wisdom of the West as in old days they were concerned by the wisdom of the East. The irrigation and high cultivation of the Delta was a hard problem of old, mastered in its entirety by the Chaldean sages, hydraulic engineers and meteorologists of no mean order; the problem is much harder to-day, but modern science is sufficiently in advance of ancient science to justify the hope that the land will again become the garden of the East, and that we shall again see men travelling from the East and also from the West, and finding a resting-place in the plains of Shinar.

The official name of Bagdad is "Dar-es-Salaam," the "Abode of peace"—a peace indeed which has yet to come,

but of which this distracted city has had little knowledge from the day of its foundation down to our own day, through the blood-stained times of Timur, Halaku, and the Tartar hordes whose descent on this land was only less destructive to its once fertile fields than the last great catastrophe, the changing of the course of the Tigris, and the terrible darkness which followed. It may surely be permitted us to contemplate the dawn of a new era of peace and prosperity in this afflicted land. Thousands and tens of thousands of industrious labourers from British India, and possibly from Egypt, will soon be flocking to the Delta of the Tigris, to begin the railway from Koweit northwards and the canals from Opis southwards. The railway from its birth will be well occupied in transporting men and materials from the Persian Gulf to the irrigation canals, renovated fields, and rising towns of Upper Chaldea. Life and prosperity to Chaldea will mean life and prosperity to the railway; and by the time the line from the Mediterranean has met the line from the Persian Gulf, the plains of Chaldea will have become ready to supply products needed both by East and West. Of all the regions of the earth, no region is more favoured by nature for the production of cereals than the lands on the Tigris. Indeed I have heard our former President, Dr. Schweinfurth, say, in this very hall, that wheat in its wild, uncultivated state has its home in these semi-arid regions, and that from here it has been transported to every quarter of the globe. Cotton, sugar-cane, Indian corn and all the summer products of Egypt will flourish here as on the Nile; while the winter products of cereals, leguminous plants, Egyptian clover, opium and tobacco will find themselves at home as they do in Egypt. Of the historic gardens of Babylon and Bagdad it is not necessary for me to speak. A land whose climate allows her to produce such

crops in tropical profusion, and whose snow-fed rivers permit of perennial irrigation over millions of acres, cannot lie barren and desolate when the Bagdad railway is traversing her fields, and European capital is seeking a remunerative outlet. The through traffic between Europe and the East will be yielding no inconsiderable income, but when this traffic is being supplemented by the transport of the abundant harvests of Chaldea, the Bagdad railway will be establishing itself as a financial success capable of satisfying the most sanguine of its promoters, men, whose conception of the railway will have given birth to the resurrection of this world-famed land.

APPENDIX A.

METEOROLOGICAL OBSERVATIONS AT BAGDAD

TAKEN BY

*THE METEOROLOGICAL DEPARTMENT OF THE
GOVERNMENT OF INDIA.*

METEOROLOGICAL OBSERVATIONS AT BAGDAD DURING 1888.

MONTH.	Pressure in inches.		Temperature Fahrenheit.				Wind Direction.	Wind velo- city. Miles per hour.	Rainfall in inches.	
	Mean.	Variation from normal.	Mean. max.	Mean. min.	Mean.	Variation from normal.			Total.	Mean rainfall in inches.
January ..	29.71	..	62.5	41.1	49.9	..	N 57° W	6	0.1	1.4
February .	29.59	..	68.1	47.0	54.9	..	N 81° W	10	2.4	2.4
March ..	29.58	..	74.2	51.7	60.5	..	S 83° W	9	0.8	1.4
April . ..	29.41	..	81.0	58.7	68.8	..	S 87° W	8	2.7	.9
May.. ..	29.38	..	94.1	70.2	80.1	..	S 60° W	8	0.7	.2
June . ..	29.22	..	102.2	76.9	88.3	..	S 46° W	7	..	..
July.. ..	29.11	..	108.3	80.2	92.6	..	S 35° W	9	..	..
August ..	29.17	..	106.3	78.6	90.9	..	S 38° W	10	..	.1
September.	29.37	..	103.4	72.8	85.7	..	S 89° W	4	..	..
October ..	29.57	..	100.2	69.1	79.1	..	N 10° W	5	..	..
November.	29.70	..	74.8	48.3	57.3	..	N 44° W	6	1.2	1.1
December.	29.83	..	60.8	42.3	49.1	..	N 14° W	4	0.5	2.0
Mean ..	29.5	..	87.9	61.4	71.4	..	..	7	8.4	9.5

METEOROLOGICAL OBSERVATIONS AT BAGDAD DURING 1894.

MONTH.	Pressure in inches.		Temperature Fahrenheit.				Wind Direction.	Wind velocity. Miles per hour.	Rainfall in inches.	
	Mean.	Variation from normal.	Mean. max.	Mean. min.	Mean.	Variation from normal.			Total.	Variation from normal.
January ..	29.74	..	55.5	37.1	46.3	..	N	..	1.5	+1
February .	29.62	..	61.5	44.0	52.8	..	E	10	7.9	+5.5
March ..	29.59	..	69.3	50.4	59.8	..	S 81° W	9	4.4	+3.0
April . ..	29.55	..	76.2	58.9	67.5	..	N 45° E	..	2.5	+1.6
May.. ..	29.40	..	91.0	69.9	80.5	..	N 10° E	9	0.0	-2
June . ..	29.25	..	100.3	76.9	88.6	..	N 2° E	..	0.0	..
July.. ..	29.14	..	105.3	78.5	91.9	..	N 8° E	..	0	..
August ..	29.18	..	106.7	79.3	93.0	..	N 4° E	2	0	-1
September.	29.36	..	100.3	70.5	85.4	..	N 5° E	1	0	..
October ..	29.54	..	90.0	61.2	75.6	..	N 12° W	0	0.1	+1
November.	29.63	..	72.1	55.1	63.6	..	N 81° E	0	4.8	+3.7
December.	29.71	..	61.5	44.8	53.2	..	S 45° W	1	1.0	-1.0
Mean ..	29.5	..	82.5	60.5	71.5	..	..	3	22.2	+12.7

METEOROLOGICAL OBSERVATIONS AT BAGDAD DURING 1899.

MONTH.	Pressure in inches.		Temperature Fahrenheit.				Wind Direction.	Wind velocity. Miles per hour.	Rainfall in inches.	
	Mean.	Variation from normal.	Mean. max.	Mean. min.	Mean.	Variation from normal.			Total.	Variation from normal.
January ..	30.04	+0.016	58.7	38.8	48.8	-1.8	..	2	0.3	-1.33
February .	29.93	-0.029	67.2	43.2	55.2	+2.3	..	4	0.1	-2.35
March ..	29.91	-0.022	73.5	49.0	61.3	+0.4	..	4	0.5	-1.38
April . ..	29.80	-0.046	87.0	61.3	74.2	+6.5	..	3	0.3	-0.85
May.. ..	29.73	+0.010	96.7	68.9	82.8	+3.9	..	4	0.0	-0.21
June . ..	29.53	-0.042	104.5	76.5	90.5	+0.8	N 20° W	5	0	-0.01
July.. ..	29.45	+0.003	110.5	79.5	95.0	+2.2	N 23° W	6	0	0
August ..	29.52	+0.017	112.1	79.4	95.7	+2.8	N 21° W	4	0	-0.13
September.	29.68	+0.011	107.3	73.2	90.3	+4.3	N 20° W	2	0	0
October ..	29.88	+0.060	92.5	64.2	78.4	+0.4	N 1° W	4	0.1	+0.06
November.	29.99	+0.012	72.3	47.9	60.1	-3.2	N 16° W	1	1.1	+0.05
December.	30.05	+0.041	58.3	39.0	48.9	-5.1	N 29° W	2	1.2	-0.79
Mean ..	29.8	+0.025	86.7	60.1	73.4	+1.1	..	3	3.6	-5.9

METEOROLOGICAL OBSERVATIONS AT BAGDAD DURING 1900.

MONTH.	Pressure in inches.		Temperature Fahrenheit.				Wind Direction.	Wind velocity. Miles per hour.	Rainfall in inches.	
	Mean.	Variation from normal	Mean. max.	Mean. min.	Mean.	Variation from normal.			Total.	Variation from normal.
January ..	30.05	+0.024	60.4	39.5	49.9	-0.6	N 51° W	2	0.4	-1.16
February .	29.89	+0.076	66.4	45.9	56.1	+3.2	S 22° W	3	1.2	-1.33
March ..	29.91	-0.021	72.7	53.7	63.3	+2.3	N	2	1.0	-0.90
April. ..	29.83	-0.023	85.8	61.7	73.8	+6.1	N 9° W	4	0	-0.19
May . ..	29.71	-0.001	93.3	66.2	79.9	0	N 35° W	2	0	-0.26
June . ..	29.61	-0.072	103.5	73.8	88.7	-0.4	N 18° W	6	0.0	+0.01
July . ..	29.45	+0.001	108.2	77.0	92.6	-0.2	N 29° W	4	0	0
August ..	29.48	-0.028	108.6	76.1	92.4	-0.6	N 19° W	5	0	-0.13
September.	29.67	-0.001	105.1	71.3	88.2	+2.0	N 1° E	3	0	0
October ..	29.88	+0.060	93.2	65.4	79.3	+1.4	N 6° W	2	0.0	+0.01
November.	29.97	-0.004	71.8	49.2	60.5	-2.8	N 10° W	2	1.7	+0.66
December.	30.00	-0.009	64.5	44.8	54.7	+0.9	N 27° W	3	1.4	-0.55
Mean ..	29.8	+0.001	86.1	60.4	73.4	+0.8	..	3	5.7	-3.8

METEOROLOGICAL OBSERVATIONS AT BAGDAD DURING 1901.

MONTH.	Pressure in inches.		Temperature Fahrenheit.				Wind Direction.	Wind velo- city. Miles per hour.	Rainfall in inches.	
	Mean.	Variation from normal.	Mean. max.	Mean. min.	Mean.	Variation from normal.			Total.	Variation from normal.
January ..	30.03	0	57.0	38.2	47.6	-2.9	N 52° W	4	0.5	-1.06
February .	30.05	+ .092	75.1	47.2	61.2	+8.2	N 14° W	3	0.0	-2.49
March ..	29.91	- .026	82.0	54.7	68.4	+7.4	N 20° W	3	0.3	-1.65
April . .	29.77	- .075	89.3	61.6	75.4	+7.8	N 22° W	2	0.2	-0.97
May . .	29.70	- .010	95.1	67.2	81.2	+1.4	N 7° W	3	0.2	-0.09
June . .	29.58	- .096	108.8	78.2	73.6	+4.5	N 6° W	3	0	-0.01
July . .	29.41	- .033	113.5	80.5	97.0	+4.2	N 34° W	2	0	0
August ..	29.45	- .055	113.1	80.9	97.0	+4.0	N 34° W	2	0	-0.13
September.	29.65	- .025	108.0	74.6	91.3	+5.3	N 18° W	1	0.0	+0.02
October ..	29.85	+ .028	93.8	63.2	78.5	+0.6	N 44° W	3	0	-0.04
November.	29.97	- .004	78.9	54.2	66.9	+3.3	N 10° W	3	0.1	-0.98
December .	30.06	+ .052	68.3	43.1	55.7	+2.0	N 45° W	3	0.2	..
Mean ..	29.8	- .013	90.2	62.0	74.5	+3.8	..	3	1.5	-8.0

METEOROLOGICAL OBSERVATIONS AT BAGDAD DURING 1902.

[illegible]

APPENDIX B.

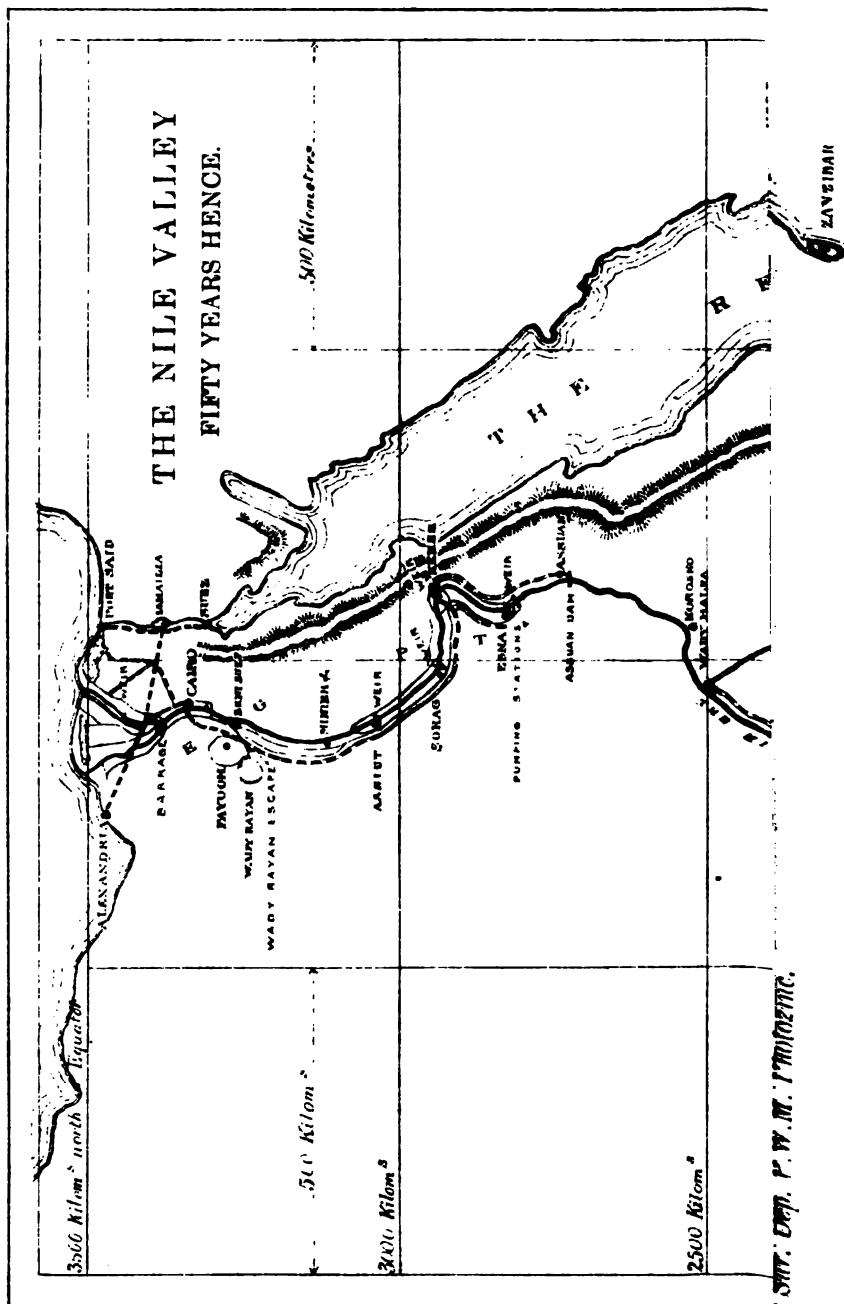
EGYPT FIFTY YEARS HENCE.

AN ADDRESS DELIVERED AT A MEETING OF THE
KHEDIVIAL GEOGRAPHICAL SOCIETY, CAIRO, MARCH 15, 1902.

BY

MR. W. WILLCOCKS, C.M.G., M.I.C.E.

*Late Director General of Reservoirs, Egypt,
Manager Director of the Daira Sanieh Company.*



EGYPT FIFTY YEARS HENCE

"THE Garden of the Lord" was the epithet applied to Egypt by Eastern writers over four thousand years ago. "Vidi viridem Ægyptum" was the observation of the Roman traveller of two thousand years ago. "Green, inexpressibly green, is the vale known as the land of Egypt" was the observation of the English traveller of fifty years ago. What will the Nile Valley appear like to the traveller of fifty years hence? Green it will surely be; but it will be no longer a beacon pointing to the permanent prosperity which the irrigation systems of the ancient world could confer on a country. It will be a beacon showing what modern irrigation and modern science can do to develop agricultural wealth. The giant works in progress and in contemplation will have put their impress on the country with no light hand. His Highness Abbas Hilmy, counselled by Lord Cromer, a guide as sage and as reliable as ever advised Pharaoh or Khalif, is carrying out works which will have taken us far beyond the great days of the Pharaohs of the 12th Dynasty, the Amenemhats and the Usartesens, whose works have left an impression on Egypt which has survived the revolutions and the catastrophes of four thousand years. The modern Egypt, which we see to-day, whose foundation stone was laid by His Highness' predecessor, the great Mohamed Ali, counselled and advised by the eminent Frenchmen whom he

delighted to honour, will, in all human probability, be completed to its very summit by His Highness Abbas Hilmy himself, who will see Egypt attain a height of splendour and magnificence which no predecessor of his ever saw; no not Ramses nor Thotmes.

Before proceeding to the description of the country as I think it will be fifty years hence, it may be well to sound one note of warning to those who will be responsible for the well-being of Egypt. The modern system of irrigation, once completed and perfected, will only be able to flourish while Egypt enjoys peace within her borders. The system of irrigation introduced by the ancient Egyptians was entirely in keeping with ancient structures of the type of the pyramids. It could defy time and even defy neglect. It was on this account that it survived every revolution and every trouble of many thousands of years; while its rival, the perennial irrigation of the Euphrates Valley, fell utterly into ruin and decay. Of the Euphrates Valley it was prophesied, as could never have been prophesied of ancient Egypt, "And Babylon, the glory of kingdoms, the beauty of the Chaldees' excellency, shall not be dwelt in from generation to generation." Perennial irrigation is no hardy plant like basin irrigation, it needs perpetual and constant attention; it is typical of the structures of our days, the dams and the weirs on the Nile, which need unremitting toil and observation to preserve them from destruction. Modern Egyptian agriculture too has been well described by Dr. Schweinfurth, the former president of this Society and the first African botanist of our day, as one unending struggle against salt. Well directed perennial irrigation converts the country into a perennial garden; when ill directed, such irrigation leaves it as a salt plain. It is on this account necessary, that, once the country has adopted this last system of irrigation, beyond which there is no other,

it should preserve peace within its borders, and ensure it beyond its borders where will lie the great reservoirs which will regulate the march of the waters of the Nile itself, and where will be settled the millions of her industrious and superb agricultural population which will have streamed southwards into the peninsulas of Meroe and Sennaar to begin there a new Egypt, which may one day rival the old.

The basin irrigation of the ancient Egyptians depended entirely on the flood waters of the Abyssinian rivers, the Atbara, the Blue Nile and the Sobat, which no engineering effort could turn out of the Nile Valley. The perennial irrigation of our days is chiefly dependent on the summer supplies of the great equatorial lakes and other reservoirs which feed the river when the tropical rains are at an end. These great lakes and reservoirs could be shut off for months and even for years at their rocky outlets; and, deprived of their supplies, the Nile in summer would dwindle into an insignificant stream incapable of supplying water to one-tenth of the Nile Valley. It is, on this account, true that the debt of £100,000,000 which Egypt owes to Europe, is in one way a blessing. The great interest Europe takes in the country will be an insurance against unfriendly neighbours interfering with her lifegiving waters. There is no evil; this world so great that it has not some "soul of goodness."

I have been reminded by Mr. James Hewat that fifty years hence the very stars in their courses will be aiding the finances of Egypt. Possessor of many financial undertakings through lapse of time, she will be on the eve of possessing the Suez Canal. The shadow of such events yet to come and the substance of other events which have come will have given the finances of the country an exhilarating buoyancy. The sums spent on great irrigation works will have brought in returns greatly in excess of the expenditure laid out on them,

and fifty years hence even the timid and the slothful, who will all along have seen lions in their paths, will have begun to see them no longer.

Fifty years hence there will be communication by steam along the whole length of the Nile Valley. By steamboat and by railway it will be possible to proceed from Alexandria and Port-Said to Mombassa. The products of the Sudan will be finding an efficient outlet by means of the Khartoum-Berber-Suakin railway. It may even be possible by railway and by steamboat to proceed from Cairo to the Cape. In this latter case a colossal statue of Mr. Cecil Rhodes will greet the railway traveller as he passes the Equator, just as Lesseps' statue greets him on entering the Suez Canal.

The Nile itself will be altered from what we see it to-day. Its waters, which to-day are in great part lost in the greatest and most terrible marshes the world has ever seen, will traverse mighty weirs and dams, and flow down well arranged and well regulated channels. From Lado to Khartoum will be one unbroken stream about 500 metres in width of pure and wholesome water, with long rows of willows by the water's side on either bank. The sudd regions and the sudd marshes even, in great part, will have ceased to exist and in their place will be the beginnings of millions of acres of rice fields and water nuts.

Indeed the Sudan government of to-day might begin the introduction of these Indian water nuts in the neighbourhood of the military stations.

The Egyptian fellah is the crown of the agricultural populations of this earth, and every effort should be made to encourage him to increase and multiply mightily and fill this Nile Valley from the Mediterranean Sea to the Abyssinian highlands. As he will be steadily advancing up the Nile he will take with him that power of wrestling with nature which

has been his attribute since the dawn of civilization. In his hands the Nile Valley may become one of the granaries of the modern world just as Egypt was of the Roman world.

Proceeding down the valley the first work we shall see will be a regulating weir at the Ripon Falls where the Nile leaves the Victoria Nyanza, a giant at its birth. This weir will have a length of some 300 metres and be not unlike the Assiout or the Delta Barrage. This type of work is the best of its kind in existence to-day. Controlled by it, the Nile will be discharging 1,500 cubic metres per second or 300 cubic metres per second according to the requirements of Lake Albert Nyanza, which will be the direct feeder of the Nile. Direct telegraphic communication between this station and all other regulating works on the river will enable the Nile to be regulated like an ordinary canal. The lands round Victoria Nyanza will be cultivated with plantain groves, coffee, tobacco and rubber plantations. The meal made of dried and pounded plantains will, as Stanley has prophesied, be one of the important foods of the world, nutritious and readily digested. At the Ripon Falls, and again at many of the cataracts of the Nile, will be electric stations and factories. The factories will be for grinding plantain meal, while the electricity generated at the falls will work the railway.

Downstream of the Albert Nyanza Lake, at Fobongo, south of Wadelai, will be the great regulating weir on the Nile. Here we shall have another work exactly like the Assiout or the Delta Barrage with a lock attached. The amount of water held up will be 4 metres and the width of the weir will be some 400 metres. It will be possible to discharge 2,500 cubic metres per second of water at any time of the year. This quantity of water will suffice for the irrigation of 8,000,000 acres of cotton, or sugar-cane in the valley of the Nile.

From Lado on to Khartoum, as already stated, though it can never be stated too often, the White Nile will be one unbroken stream of pure and wholesome water, 500 metres in width, with long rows of willows along its banks. On one of the confining banks it may have been found convenient to run a line of railway, though, I think, water communication will have been found more efficient and far more economical. The fuel here will have to be concentrated peat from the swamps themselves, or compressed water-weeds and rushes, or the fuel from willows and poplars and other water-loving trees planted along the Nile and cultivated expressly for this purpose. It is no part of my duty to-day to describe how the Nile will have been trained and led through these terrible marshes. In my recent work on "The Nile Reservoir Dam at Assuân and After" I have described how I should recommend this work to be undertaken. All estimates of the probable cost of such works can be but guesses whether we sit and ponder them in our offices for a dozen years or a dozen weeks. One year's work with two dredgers and four hundred convicts employed at training the floods, would teach more than a lifetime of speculation. The advisability of Egypt undertaking these reservoir works without any loss of time has been well brought before me by a letter I have just received from Professor Sayce, in which he says:—"As you know, archaeological facts have convinced me that the flood of a good Nile—or rather, I suppose, the perennial body of water in the Nile—is considerably less than it was only two thousand years ago, when huge boats could be navigated at the period of low Nile; and the destruction of the great forests of Central Africa by the inroads of western civilization will further diminish it. Lake Chad and the dried-up lakes connected with it are an ominous reminder of what can happen when forests are cleared away."

North again of these last-named tracts fifty years of peace and prosperity will indeed have done much in the White Nile valley downstream of the tenth parallel of latitude, a region whose prosperity and great possible development struck Dr. Schweinfurth's well-trained eye forty years ago when he went up the White Nile into the heart of Africa.

Fifty years hence Khartoum will be an important city—the terminus of the Wadi Halfa-Khartoum, Suakin-Berber-Khartoum, and the Kassala-Sennaar-Khartoum railways, and of the Lado-Khartoum line of steamers. It will also find itself the depot of the Sennaar and Meroe peninsulas of to-day or the new Egypt of fifty years hence. The Blue Nile as it traverses the rich plains which lie on either hand, will have been harnessed and will have become another Sutlej or Jhelum, while the country will have been altered as the Punjâb has been. Thirty years ago the sandy plains of the Punjâb supported a scanty population, which depended on a poor and uncertain rainfall for a precarious existence. To-day these same plains are covered with millions of acres of cereals and teeming villages depending on the flush irrigation from the great canals which the Indian Government has constructed within recent years. Fifty years hence the Meroe and Sennaar peninsulas will be traversed by perennial canals and will be already becoming one of the prosperous countries of the arid and semi-arid zone. These plains possess a soil which is in every respect similar to the soil of Egypt. It has come from the same sources, it has been formed in the same way. The great difference has been that while the Nile in Egypt has been able to overflow its banks within historic times, the Blue Nile has not been able. This latter river has a trough some twelve or fourteen metres deep and rises in flood to a height of eight or ten metres. It has consequently not been able to overflow its banks. The light monsoon

rainfall has covered the country with dense bushes, and the absence of agriculture has made it unhealthy. The combination of uncertain rainfall and malarious surroundings has debased the population, and made these tracts singularly uninviting. The very richness of the soil has been the cause of this ruin. Nothing will ever be done with these tracts, potent with future wealth, until flush irrigation has been provided. Colonies of settlers who clear their small plots in the midst of malarious surroundings, and get enlarged spleens when it rains and who die of starvation when it does not rain, will not reclaim this country. Fifty years hence, at Sennaar and again at Abu Haraz, there will be weirs such as we see at the head of the Delta; Egyptian regulators just upstream of Indian weirs. There will be two works like Mougel's Barrages; and immediately below them, two weirs like those which Major Brown has recently constructed. Each of these combined works will hold up six metres of water in winter and two metres in flood, and from above them will start canals which will irrigate the Sennaar peninsula right up to the White Nile and the Meroe peninsula up to the Atbara. A rich soil endowed with flush irrigation will be attracting hundreds of thousands of Egyptians from the densely packed provinces of Kena and Girgeh, who will be converting these desolate plains into smiling fields. The prospect of flush irrigation on a fertile soil will have insured this in the same country where to-day it seems hopeless to get a single bonâ fide immigrant. And indeed it seems difficult to understand why any Egyptian should be induced to leave his pleasant country for a distant land with nothing before him except one unending struggle to raise water some ten metres in summer and less in flood, a thing which he can do at his own door whenever he feels inclined. The provision of running canals and flush irrigation will have

changed all this, and the Egyptian emigration to the New Egypt will have been firmly established fifty years hence. If reclamation on a gigantic scale has been possible in the sandy plains of Upper India, it will also have been possible in the rich soil of the Blue Nile peninsulas ; but in the Nile Valley, as in the Punjâb, the provision of flush irrigation will have preceded the transformation and not followed it, as some have vainly imagined for this country.

Between Dongola and Assuân the date-palm will have much increased. The considerable incomes earned by the Dongalawi and Berberi population in Cairo and the important towns of the Delta will have been largely spent in ameliorating the condition of their native country, and in no way will this have been done more than in the extension and improvement of the dates grown in this tract. Fairly well-to-do proprietors are needed for an extension of date cultivation, as the preliminary expenses are high and the palms themselves take time to mature. These men, who can afford to wait, will have found date cultivation so profitable that improved qualities of dates will have been introduced, and, among them, varieties to equal the golden dates of Algeria which are so popular in Europe and America. These varieties will have been introduced through the medium of the Ministry of Agriculture.

Fifty years hence there will assuredly be in Egypt a Ministry of Agriculture which will interest itself in increasing the prosperity of the country without an eye to taking anything out of it. This singleness of aim will be the distinguishing feature of the Ministry of Agriculture. To-day, the Khedivial Agricultural Society, under its distinguished president, H.H. Prince Husein Pasha Kamel, with its energetic and able secretary, Mr. Foaden, is doing the utmost that any single-handed Society can do to arrest

the deterioration of Egyptian cotton, which is becoming more pronounced every day, and to introduce suitable manures. Fifty years hence we shall have a Ministry of Agriculture with some two score agricultural experts who will not be arresting deterioration but be adding daily to quality. The necessary funds will have been placed at their disposal to accomplish this task. Under the old Pharaonic system of basin irrigation the Nile flood itself was the Ministry of Agriculture, and the Irrigation Department sufficed to supply all the requirements of the country. Under the modern system of perennial irrigation the Irrigation Department does only half the work, and the other half remains to be done by a recognised department of agriculture with large funds placed at its disposal. While Egypt was semi-bankrupt, the Ministry of Finance and the Public Debt Commission sufficed to extract all which could be extracted from the country. As the fellaheen used to say, "however much you may shake an empty bag of flour, you can always knock some more flour out of it by striking it with a stick." Such methods sufficed when Egypt was poor. During the last three or four years, however, Egypt has been rich and has had other needs. These three or four years these two plain and elderly but jealous sisters have been trying to fit their large and tenacious feet into the unoccupied glass slippers which were found lying in the Prince's ballroom when Egypt became a wealthy country. Fifty years hence, and indeed long before that, the two sisters will have loyally recognised Cinderella, contentedly occupied their proper field, and the Ministry of Agriculture will have been firmly established as the necessary complement of the Irrigation Department.

What will be the field in which the Ministry of Agriculture will be working fifty years hence, and what will be

the nature of its undertakings ? It will be working in the whole Nile Valley through its length and its breadth. It will have for ever removed from the statute book the prohibition of tobacco cultivation, and have substituted in its place the encouragement of tobacco cultivation to the utmost. Egypt will indeed have become one of the recognised producers of high grade tobacco. The Egyptian will again be seen, seated under his own vine and his own date-palm, freely smoking his home-grown weed and praising its quality to all his neighbours. The Ministry will have recognised that the Nile Valley from Abyssinia to the Mediterranean Sea has a soil which only needs irrigation and scientific treatment to return a hundredfold. It will also have realised that Egypt proper, through gifted with a superb climate, has a very restricted area, and that quality and not quantity should be the watchword of this part of the valley. It will have understood the varying needs of the new Egypt on the Blue Nile and the distant countries north and south of the tenth parallel of latitude, where quantity and not quality will be long the only practical goal. To insure all these ends, the Agricultural Department will have located in the different regions, experimental farms which will help to fix the nature and the method of cultivation of the plants best suited to those tracts. It will be bestirring itself to find the ingredients of the manures and the methods of cultivation best suited to hurry up the ripening of crops in the north and to retard their ripening in the south. It will have introduced agricultural banks in the advanced village communities of Egypt through the agency of the Copts, who have the necessary amount of confidence in each other to insure the success of such undertakings. It will be advancing considerable sums at very moderate rates of interest to syndicates of farmers who will be reclaiming the derelict plains of Sennaar and

Maroe. It will have its *weather bureau* forecasting seasons and weathers and disseminating information with the aid of wireless telegraphy. It will have its *bureau of animal industry* inspecting imported beasts and encouraging the introduction of useful animals after a bold examination, and not prohibiting everything in a timid and ignorant way. This bureau will have its division of dairy industry studying compositions of butter suited for hot countries. It will have its *bureau of chemistry*, studying food adulteration, compositions of soils, and perfection of agriculture viewed from the chemical point of view. It will have its *bureau of plant industry* with its division of entomology, introducing useful fertilising insects, and destroying harmful ones. This bureau will have its division of botany improving the quality of seed grain and insuring its distribution among the cultivators; it will have its division of vegetable physiology and pathology, studying diseases of plants and cereals and finding efficient remedies; it will have its division of pomology attending to the fruits of the country and their development; it will have its biological division, studying how to introduce and protect useful birds and destroy harmful ones. It will have its *bureau of soils*, mapping the soils of the whole Nile Valley. It will have its *bureau of forestry* for the whole of the Sudan. It will have its *bureau of experimental stations* collecting information worth untold gold to the agricultural community. It will have its *bureau of foreign products*, and its trained agents will be travelling over the whole world and forwarding to Egypt from every quarter of the globe the grains and plants which give promise of being useful in the Nile Valley; a division of this bureau will be interesting itself in the introduction of new and useful implements of husbandry. It will have its *bureau of foreign markets* studying the world's markets, and instructing the country as

to the most profitable crops to grow in each season. It will have its *bureau of pisciculture*, attending to the development of fisheries. It will have its *bureau of statistics*, which will be collected by trained experts and not by village sarrafs who could not tell a field of barley from one of wheat to save their souls : this bureau will have its division of publications, disseminating knowledge in simple language and bringing it home to the people. In a word it will be full of courage and initiation and following in the steps of the Agricultural Ministry of the United States of America, it will be looking with single eye to the increase of the wealth of the country, without any design on the purses of its inhabitants. With an irrigation department, as advanced as any in the world, insuring the proper irrigation of the country ; and with an agricultural department, in the hands of trained experts, Egypt will be showing to the world that irrigation can do when it is given a free hand.

Fifty years hence we shall find the country protected from high floods by escapes into the deserts. Such escapes will have been formed by either the construction of powerful weirs across the Atbara leading off the flood waters into the desert; or by the construction of a weir at Hannek or Kaibar leading off an escape into the El Kâb depression to the west of Dongola; or by an escape leading into the Wady Rayan south of the Fayoum. The best of these three projects will have been completed before fifty years have passed. If the Wady El Kâb has been found suitable it will certainly have become the escape of the Nile. If it has not been found suitable the Wady Rayan will have taken its place. I have calculated that such an escape could be constructed for £3,000,000. If the Wady Rayan escape has been constructed in imitation of the ancient Lake Mœris, we shall have a statue of Mr. Cope Whitehouse on the top of the

Mesaigêga cliff contemplating the inland lake of 600 square kilometres, which will be covered with sailing craft and be one of the winter pleasure resorts of Europe.

The Assuân dam, fifty years hence, will have been raised to its full height. The giant lakes at the Equator and possibly in Abyssinia, and the training of the White Nile through the swamp regions will have assured to the whole Nile Valley a perennial supply of water amply sufficient for all its requirements.

The Nile in flood, as well as in winter and summer, will have been maintained at a level sufficiently high to allow of the utilisation of the water power to its utmost limits. The permanent water power represented by 750 cubic metres per second falling 16 metres, or 150,000 H.P. will have been utilised in works for storing electricity and permitting of the perennial irrigation of the tract from Assuân to Esna on both banks of the Nile, sugar factories and other manufactures at Assuân and Kom Ombos, and railway haulage north and south of the dam as far as it can be profitably employed. A powerful pumping station at the head of the Ramâdi Canal will be pumping water into that canal and irrigating flush the whole country as far as Esna and Mataana. A canal taking out from above the dam will be supplying perennial irrigation to the 50,000 acres of land in the Kom Ombos plain and creating a new district.

The Nile itself will be trained with stone spurs in imitation of the works of Ramses in Nubia, and we shall have from Wady Halfa to Cairo, a channel down the middle of the river which even at the lowest time of the year will suffice for boats drawing three metres of water. Egypt will no longer be trying to help on the railway traffic at the expense of its navigation, or be proud of the fact that she is not actively hurting navigation by obstructive tolls. She will

have recognised that a river which always flows northwards and on which the winds nearly always blow southwards is an extraordinarily efficient and economical means of communication and a very valuable asset of the country. The training works will not only have improved the navigation of the river, they will have abolished all the unsightly sand shoals and tens of thousands of acres of flying sand, and converted them into well cultivated foreshores green with vegetation. This revolution will have made the Nile one of the most agreeable and pleasant rivers to navigate in the world. Gifted with its bracing winter we shall find that fifty years hence the Nile will be covered with pleasure boats and steamers which will be the winter residence of thousands of rich men from America and Europe. Half a dozen steamer and hotel companies will be finding room to work in and to flourish. The Nile will be as crowded in winter as Switzerland will be in summer.

Fifty years hence the Sanitary Department will have completed its study of the book of Leviticus, and have made rural Egypt clean. It will have fenced off all the tanks of filthy water round the villages, planted them thick with willow cuttings and rendered them perfectly innocuous. The department will have turned to first principles and the villages will have become suitable habitations for human beings.

Fifty years hence the Nile at a point north or south of Esna will be provided with a double weir of the type Major Brown has made us familiar with at the head of the Delta. From upstream of this weir will be led two canals at a high level which will be providing perennial irrigation to the whole country on both banks of the river from Esna to Naga Hamadi. North of Kena will be located another double weir, from above which will start two canals which will be

providing perennial irrigation to both banks of the river as far as Tahta. At Sohag will be a third double weir feeding right and left bank canals which will carry on the perennial irrigation on both banks of the river as far north as Manfalut. Land in Girga will be considered cheap at £100 per feddan. The unsightly mounds of silt which follow the basin canals for hundreds of kilometres and which are to-day the despair of irrigation engineers will have begun to disappear. The silt will have been used as manure for the fields, and no annual clearances will have added to the mounds. The ancient Egyptians understood thoroughly how to utilize the flood waters of the Nile, and modern Egypt is learning how to utilize it when it has it all the year round; but the great lesson which Egypt and the Sudan have to learn is that the Nile has an excellent winter discharge which has as yet not been taken advantage of. With this lesson once learnt, all these works will be undertaken and flood and winter irrigation be provided to the whole of Egypt quite independently of the Reservoirs. The fields will have flush irrigation from the 1st August to the 1st April, while the saturated subsoil will feed tens of thousands of wells and keep up the summer supply of the Nile itself, as we see to-day in part of Menufia, Kalyubia and northern Geeza. A well saturated subsoil is itself a reservoir of no mean order. The works will barely have been completed and the two-season irrigation begun, when the effects of the training works in the sudd regions of the White Nile and of the reservoirs at Lake Albert, Lake Victoria, and possibly Lake Tsana, will have commenced to be felt, and the country be converted from single to double and then to perennial irrigation.

Fifty years hence there will in all probability be stationed at the Esna weir a factory for the extraction of pure nitrates from the nitrate deposits in the strata which lie between

the sandstone and limestone masses in the hills bordering the Nile Valley and which come to the surface along this reach of the Nile. Nile water is exceedingly poor in nitrates, but nature has placed within reach of the country an inexhaustible supply of nitrates. If it be true that the phosphates found by the Geological Survey near Kena are in considerable and workable quantities, here also will be an industry which will greatly aid agriculture. The extraordinary richness of the leguminous crops of Egypt proves conclusively how largely Nile water is supplied with potash. Nitrates largely and phosphates moderately are all that are needed to make agriculture in the Nile Valley absolutely ideal. A superb climate, a cloudless sky, timely irrigation, rich fertilizing water, and a fertile soil. Nature can go no further.

With plentiful irrigation all the year round it will have been found possible to devote large areas of land bordering the desert to extensive lucerne fields, and to cultivate in parts of the deserts themselves the best kinds of South African Karoo bushes. This will have permitted of the rearing of tens of thousands of ostriches, which will have found Upper Egypt an ideal climate. Fifty years hence large areas of desert bordering the cultivated land will have been fenced off and stocked with these very profitable birds whose food consists principally of green or chopped dry lucerne, and who want nothing beyond a climate like that of Egypt to develop a lustrous plumage. The Ministry of Agriculture will not have been in existence many years before this industry will have started.

Fifty years hence the whole Nile Valley from Assiout to Cairo will be one perennially irrigated plain covered with sugar and cotton factories and even with cotton mills. Thanks to the enlightened development of her irrigation system, initiated by Major Brown, carried on by Mr. Wilson

and Mr. Webb and completed by Mr. Verschoyle, Mr. Clowes and Ismail Bey Sirry, the whole valley from desert to desert past Minieh and Beni Suef will be as well cultivated as Menoufia is to-day; and with her equable climate will be the garden of the Nile Valley. Her position in the desert will protect her from autumn fogs, while the great width of the perennially irrigated valley will guard her from that excessive summer heat which has hitherto prevented the Upper Egyptian cotton fibre from attaining its full strength. The thoroughly irrigated and cultivated valley will enjoy in summer an equable climate which will permit of her cotton fields slowly developing their fibre, of her early planted sugar-cane and beetroot fields coming to a full growth in time for the winter crushing, and of a European community of planters living the healthy outdoor life which is so marked a feature of similarly situated lands in India. I can conceive of no tract in the arid zone of the world better suited for healthy tropical cultivation than the wide stretch of the Nile Valley north and south of Minieh.

Along the sand-driven deserts which skirt the western valley in this reach, and which are seldom seen as they lie away to the west of the Yusufi Canal, fifty years hence there will be running a dyke which will permit of the sandy deserts being thoroughly saturated with water and kept in a condition of tilth capable of supporting plant life. In these ~~deserts~~ the Agricultural Department will have fenced off a width of some two or three kilometres of land and protected it from the flocks and herds of the Bedouin Arabs along the western edge of the Nile Valley. Within these fences there will have been planted suitable trees, willows and palms, tamarisks and grasses, which will have not only fixed the desert sand and prevented it from injuring the cultivated land, but have reclaimed and converted some 30,000 acres of

desert into a veritable fuel and timber preserve. Intelligent management will have secured this, fifty years hence.

Fifty years hence the Fayum will be an oasis of some 400,000 acres of cultivated land. Three years ago in the second edition of my book on the Egyptian Irrigation I had summed up the position of this province by saying that "truly there is a great field for any energetic and capable engineer in the Fayum." The words had scarcely appeared in print when Mr. Clowes arrived in Egypt and was struck by the capacities of this half derelict province just as I had been. His untiring energies and intelligently executed works have begun to put their impress on the lands, which fifty years hence will be reaping the full benefit of the works which to-day are in full execution. The Wadi Rayan escape basin, which will be an escape for the excess flood waters of the Nile and will in consequence be kept at too low a level for supplying the Nile with water, will be sufficiently high to be utilised for the whole western half of the Fayum.

To the north of Beni Suef will be the outlet and inlet canal for the Wady Rayan escape basin. This gigantic work will be one of the greatest irrigation enterprises ever undertaken. It will be wonderful how history will repeat itself. Let us cast our eyes over the development of ancient Egypt and see how, on the eve of changing the whole Nile Valley into perennial irrigation we are just where the Pharaohs of the 12th dynasty were. I quote from my lecture delivered last October at the Glasgow International Congress.

"If we cast back our view to the dawn of Egyptian history, we can picture the Nile Valley as consisting of arid plains, sand dunes, and marshy jungles, with reclaimed enclosures on all the highest lands. Every eight or ten years the valley was swept by a mighty inundation. We may well imagine with what awe the ancient Egyptians contemplated laying

their hands on the great river, and saying to it 'thus far and no further.' The seeds of future success lay in the resolve of King Menes' engineers to confine their attention to one bank of the river alone. It was the left bank of the river which history tells us was first reclaimed. A longitudinal dyke was run parallel to the stream, and cross dykes tied it to the Lybian hills. Into these basins or compartments the turbid waters of the flood were led by natural water-courses and artificial canals; and meantime the whole of the right bank, and the trough of the river itself were allowed to be swept by the floods. It must have been on this wild eastern bank that were conducted all the hippopotamus hunts which are crowded on the pictures of buildings of the early dynasties. In all probability, the first six dynasties contented themselves with developing the left bank of the Nile. As, however, the population increased, and with it the demand for new lands, it became necessary to reclaim the right bank of the river as well. The task now was doubly difficult, as the river had to be confined to its own trough. This masterful feat was performed by the Great Pharaohs of the 12th dynasty, the Amenemhats and the Usartesens, who, under the name of Sesostris, usurped the place of Menes in the imagination of the ancient world. They were too well advised to content themselves with repeating on the right bank what Menes had done on the left. By suddenly confining the river they would have exposed the low-lying nomes of Memphis and Lower Egypt to disastrous inundations. To obviate this, they widened and deepened the natural channel which led to the Fayum depression in the Lybian hills, and converted it into a powerful escape to carry off the excess waters of high floods; and so successful were they in their undertakings, that the conversion of the Fayum depression into Lake Mœris was long considered by the ancient world as one of its greatest

wonders. They led the flood into the depression when it was dangerously high, and provided for its return to the river when the inundation had come to an end. By this means, they insured the lake against being at a high level during a period of flood. The gigantic dykes of entry and exit were only cut in times of emergency, and were reconstructed again at an expense of labour which even an Egyptian Pharaoh considered excessive. As years rolled on the Nile widened and deepened its own trough, to which it was now confined; and eventually the time came when Lake Mœris could be dispensed with without danger. It was gradually reclaimed and converted into a province."

The first dyke to be constructed in Egypt was the Koshesha dyke, which protected the southern boundary of the Memphis nome from the Nile in flood. At its base and round its abrupt south-eastern corner swept the waters of Lake Mœris as they returned to the Nile. This particular point must have been from time immemorial an object of preoccupation and anxiety in every flood. It was "par excellence" the corner. To-day the village which stands here still bears the name of "El Zawia" or "the corner." The Koshesha dyke was the most important dyke in Egypt seven thousand years ago. It is the most important to-day. It was the first to be constructed. It will be the last to be abandoned. When the final coping-stone has been put to the conversion of the whole of Egypt to perennial irrigation, then and only then will this dyke be abandoned and ploughed up. It will have lasted over seven thousand years. We are truly in a wonderful land. "It will surely be, that, at the time the Nile Valley " is being finally converted to perennial irrigation, there will " begin the resurrection of that other wonderful old-world " country, the valley of the Euphrates, which has so long " lain neglected and uninhabited. The Euphrates Valley

“ railway will certainly put life into that long-buried land, “ and we shall read of great weirs and irrigation works on “ the river Euphrates,” undertaken and brought to a successful completion by German engineers, working in healthy rivalry with the engineers on the Nile and the Ganges, and suggesting new developments in the oldest science in the world.

Fifty years hence an iron syphon to the south of Wasta will be conveying perennial water across the Nile for the irrigation of the east bank to the gates of Cairo and beyond to Kubbeh and Kalyub. Many of the Cairo streets will be skirted by masonry channels carrying perennial water, which will be utilised for gardens and for washing and keeping clean the streets of our city. The streets fifty years hence will be paved with asphalt bricks and be daily washed, and the Director General of Works will be contented. We who live in Cairo will not be compelled to read, in silence and impotence, of hour heavily taxed city with its 2,780,000 square metres of streets having a niggardly sum provided which suffices only for the maintenance of 385,000 square metres, or barely 14 per cent. Fifty years hence this will not be so. Egypt will have forgotten that it was a bankrupt country, and a generation will have come which will have had no knowledge of bankruptcy, and will have made Cairo a capital worthy of the Nile—a worthy successor even of Memphis and mighty Thebes. Miserable sums will not be doled out. Money will be given by handfuls, and our city will be *the* city of the North African Continent. Fifty years hence the whole city will be well lit, the poor quarters as well as the rich men’s quarters; the streets will be all paved and will be clean; the inhabitants of the poor quarters will not wade through putrid mud every time there is a fall of rain, or be blinded with dust when there is no rain. Broad avenues of trees down the line of the abandoned Ismailia

Canal will have taken the place of the unsightly dumping grounds of city refuse which we see to-day and which we cannot avoid. That poor and filthy Bulak quarter, which lies between Cairo and the N.W. wind, and lades the zephyr itself with sewer airs, will have been taken in hand and purified. One has only to visit the handiwork of Mr. Chélu at the government printing press in this very quarter to learn what an energetic and capable engineer can do when he is given a free hand, even in Bulak. Imagine Mr. Perry, with his striking power of giving return for money, with £120,000 per annum at his disposal instead of the paltry £E.40,000, which he actually receives!

The Nile will be spanned by three or four bridges to accommodate her traffic, and we shall not be jostling camels and donkeys laden with manure, or dodging motor cars and American spiders, on one single narrow bridge with its sham footpaths. Cairo itself will have spread from Mataria to beyond the Upper Egypt railway. The Ministry of Agriculture will have snatched large areas from the builders' hands and reserved them for recreation grounds and health-giving lungs. Esau will not have been allowed to sell the whole of his birthright for a mess of pottage. Public Works regulations will have insisted on garden areas being preserved round all the houses, of the heights of the houses bearing some proportion to the widths of the streets, and of the levels of the floors also having some relation to the streets on which they stand. But above everything else the sanitation of Cairo will have been put on a sound basis. Pools of blood from the slaughter-houses and festering water from the tanneries, which used to pollute the air and plague Cairo with horrible smells when the south wind blew, and which have been considerably contracted within recent years, will have been be contracted clean out of existence. The State

will have learnt to consider payment in health for money spent as current coin equal in value to golden sovereigns. The streets will be provided with latrines and lavatories for men, women and children, and the abominations of to-day will be unknown. The drainage of Cairo will have been carried out on the broad lines laid down by Dr. Milton—lines suited to Cairo and not to Berlin or Edinburgh. Fifty years hence we shall be as interested in the living as in the dead and we shall have many things besides museums of antiquities to show to our visitors. We shall, moreover, be able to walk on the pavements of our streets and show them, without being covered with shame.

Fifty years hence Lower Egypt will possess again the same cultivated area which she had in Roman times, but this whole area will be double and not single cropped per annum. The hundreds of ruined mounds which stand in the midst of vast desolations between Alexandria and Port Said will have begun again to be inhabited and to be surrounded with cultivation. A million of acres will have been added to Egypt. Whether the desolation we see to-day was the work of the troubles and distractions of a thousand years or of some severe earthquake which caused a serious subsidence of the land, we need not here inquire. We have more to do with the future than with the past. Tanis or Zoan will never again be the city she was when the Hyksos were reigning in Egypt and when Joseph stood before Pharaoh, but she will not be sitting desolate and dejected as she is to-day. Far from it. Here again before fifty years are over there will have been a return to first principles, and following in the steps of Menes and Usartsen we shall first have redeemed the lands from barrenness and then gifted them with perennial irrigation.

In Ptolemaic and Roman times the whole of this land, known to-day as Berâri or waste lands, was cultivated. The

wilderness bordering the lakes was known as "ard zafran" or the choice land. According to local tradition, partially confirmed by the presence of Pharaonic summer canals and cyclopean dykes, some of the tracts were once covered with vineyards, while the rest were divided into enormous basins of some 50,000 acres each and planted with wheat. They are credited with having supported a dense population. They are now a barren plain, from which rise numberless mounds strewn with bricks and pottery. Fifty years hence the vain effort to reclaim these lands by drainage alone will have been abandoned. The drains will have become canals and escapes, and indeed the word "escape" will have been introduced into our vocabulary as it has been introduced in India. The old canals and escapes which have been converted into drains will again have been utilised as carriers of flood water. The whole country will have been converted into basins such as Amenemhat and Usartesen would have loved to contemplate, and will have been washed and turned into fertile soil. While basin irrigation is being fast abandoned in Upper Egypt, here on the edges of the brackish lakes which border the Mediterranean will the same basin irrigation be employed to give new life to these derelict tracts, and as each tract is reclaimed and rendered fit for perennial irrigation it will be gifted with this higher system by the aid of the waters brought down from the great equatorial reservoirs. By the time these reservoirs and training works will have become sufficiently established to provide unfailing supplies throughout the year, will these lands have been rendered fit to utilise them. Here again it is none too early to begin these basin works so that when the perennial supplies are ready they may be immediately used. Fifty years hence the word "Berâri" or waste lands of the north will have died out of Egypt. Agricultural railways and navigable canals will be

threading them in every direction, and a busy agricultural population will be reaping from them a rich harvest.

Fifty years hence, in addition to the Zifta weir under construction to-day, there will be a weir at the mouth of the Rosetta branch of the Nile and another at the mouth of the Damietta branch. Salt water will not travel up the Nile. The cotton crop of Lower Egypt will be fifty per cent in excess of what it is to-day, not only in quantity, but also in quality. Cotton in summer and Egyptian clover in winter will be the prevailing crops of the country, and by means of this rotation and suitable manures there will be no exhaustion of the soil. With a climate, a soil and a river such as ours will be, and a Department of Agriculture in the hands of experts, Egypt under perennial irrigation will be renewing its youth each recurring year as it has done for seven thousand years under basin irrigation. Dairies will be scattered over the face of the land. Behera will have become a new province. The Rayah Behera, that monument of Mr. Foster's perseverance and skill, will have been doubled in size and will have sent branch canals to Mex and the tracts to the south of the Mareotis Lake. Artificial manures will have come to the aid of the Nile water and permitted of the reclamation of sandy areas which to-day are neglected. Lake Aboukir, fifty years hence, will be one stretch of 30,000 acres of cultivated land, a living witness to the courage and dogged tenacity of Mr. Lang Anderson. The first man to put his hand on the Egyptian lakes had oak and triple brass on his breast, and he has done splendid pioneer work for this country. The reclamation of Lake Edku will be far advanced fifty years hence. Aboukir will have shown the way. Lakes Borillos and Menzaleh will be as they are to-day, but the fishing will have been greatly improved. The Agricultural Department will have followed the example of China, and

will have introduced a new industry into the country. It will be possible to say of Egypt what General Tchangki-tong said of China at the Paris International Congress of 1889. I quote from my book on Egyptian Irrigation.

"I may add that without these gigantic irrigation works, the Chinese could never have carried to such a pitch of perfection one of their most important industries. I speak of pisciculture. Thanks to the abundance of water, the whole of my countrymen, instead of contenting themselves with covering with their fishing boats, the seas, rivers and lakes of our country, have devoted themselves to the breeding of fish. The spawn is every where carefully collected; far from leaving it to take its chance the peasant gives this source of wealth a safe shelter in some spot when a perennial supply of water can be assured. The irrigation reservoirs team with fish. During winter the rice fields are fallow; the water is led into them and they are instantly full of carp. This industry allows us to make fish a considerable factor in the food of our people. The fish are either eaten fresh; or, salted and dried, they are despatched to all parts of the Empire and sold at a price which is remunerative though it is exceedingly cheap."

I have so far tried to give as vivid a picture, as I am capable of giving, of what we may expect the Nile Valley to be after an interval of fifty years. The development of which I have spoken may seem to some impossible of attainment, but let such forget the snows and fogs and sluggish cultivation of their native countries and realise what irrigation can do under cloudless skies, in a stimulating climate, and with a genial soil. The modern world, under the guiding and of the Great European races or their descendants, has been slow to adopt irrigation—that oldest of old world sciences. The roads and railways, and the

mines and factories of Europe are taken to every land, but the modern world stands hesitating before that science which was hoar with age thousands of years before railways were dreamt of. In the new countries of the southern hemisphere and in the arid and semi-arid regions of America money has been spent in millions on railways and communications while it has barely been spent in thousands on irrigation works ; and yet in these arid countries the only permanent development possible will depend on gigantic irrigation works supplying all the deficiencies of nature. The resurrection of Egypt under the guiding hand of Lord Cromer is helping the cause of irrigation more than any other factor in this our age. The cause of irrigation indeed leans confidently on Egypt and is proud to call her her eldest child. In the great development of irrigation which the world will see before many years are over, Egypt will again be, as she was in the past, the beacon pointing the way to the attainment of stable wealth. It is this aspect of the question which gives to the development of this country, by means of its great irrigation works, an importance which reaches far beyond the limits of the Nile Valley.

I bring this lecture to a close by expressing my genuine pleasure at having been privileged to address a meeting of the Khedivial Geographical Society on so fascinating a subject as the development of the Nile Valley. I can make no boast to take my stand by the side of your former distinguished president, Dr. Schweinfurth, and the scores of men who have made the River Nile an open book to the civilized world, but I am proud to count myself among the next generation of workers, the men who utilise these great discoveries and make them subservient to the advancement of the world. It can be no consolation to men like Dr. Schweinfurth to know that their thrilling discoveries are being depicted

on plans and registered in atlases and are going no further. It was not for such barren triumphs that these men underwent the trials and difficulties of scores of years. Looking forwards fifty years, we as well as they can foresee a real compensation for our labours and an abiding triumph for our perseverance, in the greatly enhanced value of the Nile Valley, and the amelioration of life of the whole of its inhabitants. The great discoverers have done their work so well, that we irrigation engineers are being urged as by a trumpet so show no slackness in ours; but, having done the very utmost our abilities have allowed us to do, we hope to be able to point to the great works on this mighty River, and to say with humility, not with boastfulness, "*Si monumentum quæris, circumspice.*"

CORRIGENDA

PLATE 1.—“ 1749 ” should be “ 1849.”

„ 5.—“ Kilometre 205 ” should be “ Kilometre 62.”

„ 8.—“ Kilometre 62 ” should be “ Kilometre 205.”

PAGE 30.—Line 12 from bottom, “ concerned ” should be “ conceived.”

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